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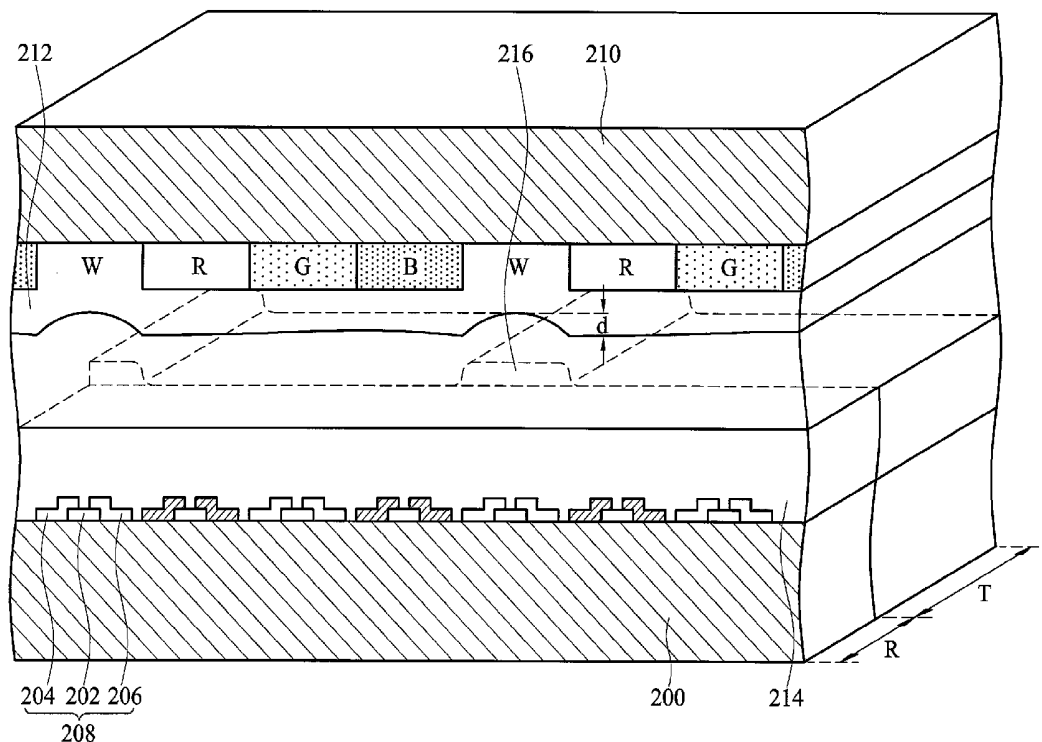
(19) **United States**(12) **Patent Application Publication**
Hung et al.(10) **Pub. No.: US 2007/0247572 A1**(43) **Pub. Date: Oct. 25, 2007**(54) **TRANSFLECTIVE LIQUID CRYSTAL
DISPLAYS AND METHODS FOR
FABRICATING THE SAME**(30) **Foreign Application Priority Data**

Apr. 21, 2006 (TW) 95114273

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(TW)(51) **Int. Cl.**
G02F 1/1335 (2006.01)(52) **U.S. Cl.** 349/114(57) **ABSTRACT**

A transflective liquid crystal display. A first substrate comprises a plurality of pixels, each pixel comprises a plurality of sub-pixels and each sub-pixel comprises at least one transmissive and at least one reflective regions. A second substrate is opposite to the first substrate, divided into a plurality of regions corresponding to the sub-pixels, and at least three of the regions are color regions and at least one of the regions is a fourth region. A first covering layer covers the first substrate, wherein the first covering layer in the transmissive region corresponding to the fourth region is substantially thicker than that corresponding to the three color regions, and the first covering layer in the reflective region corresponding to the fourth region has a thickness substantially equal to that corresponding to the three color regions. A liquid crystal layer is disposed between the first and second substrates.

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Hsinchu (TW)(21) Appl. No.: **11/554,657**(22) Filed: **Oct. 31, 2006**

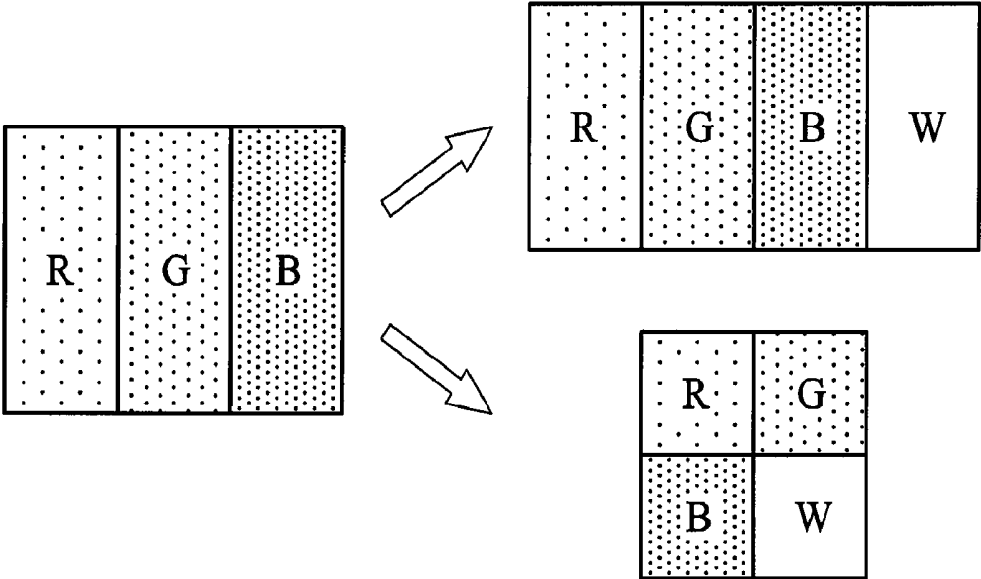
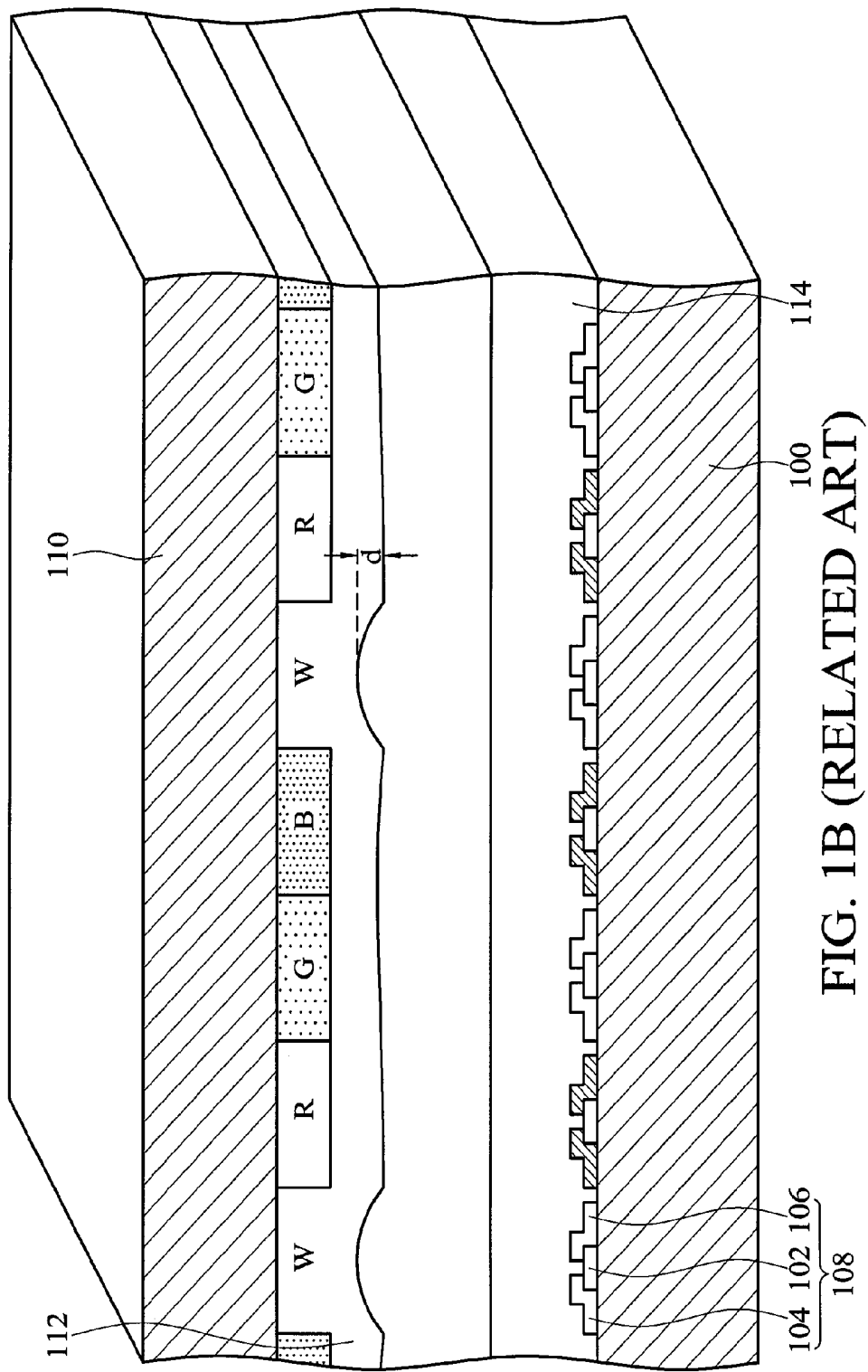
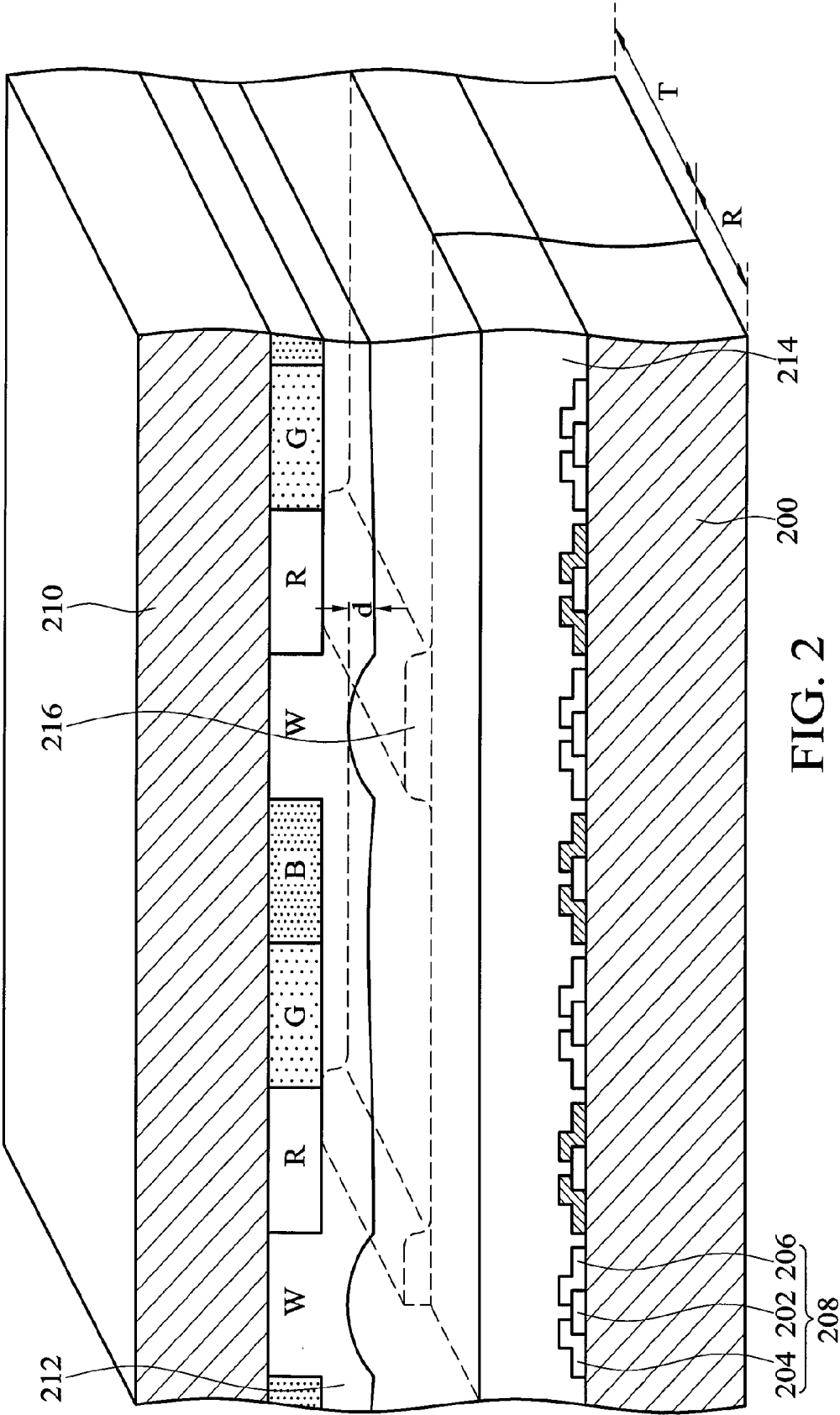


FIG. 1A (RELATED ART)





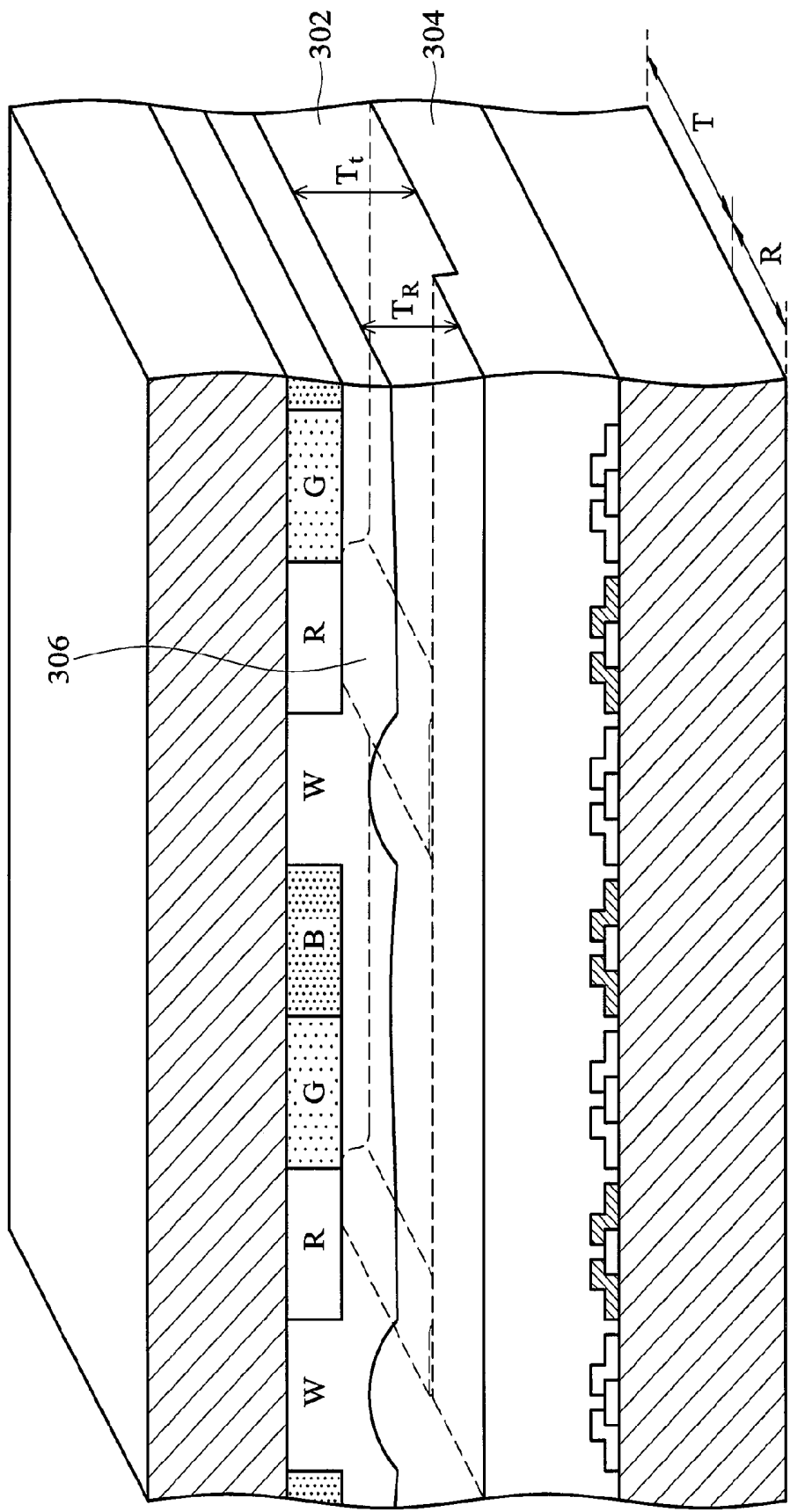
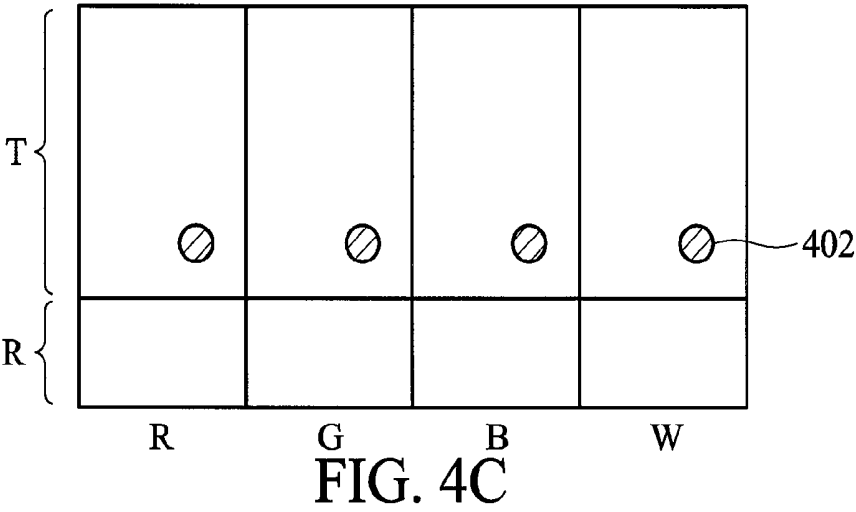
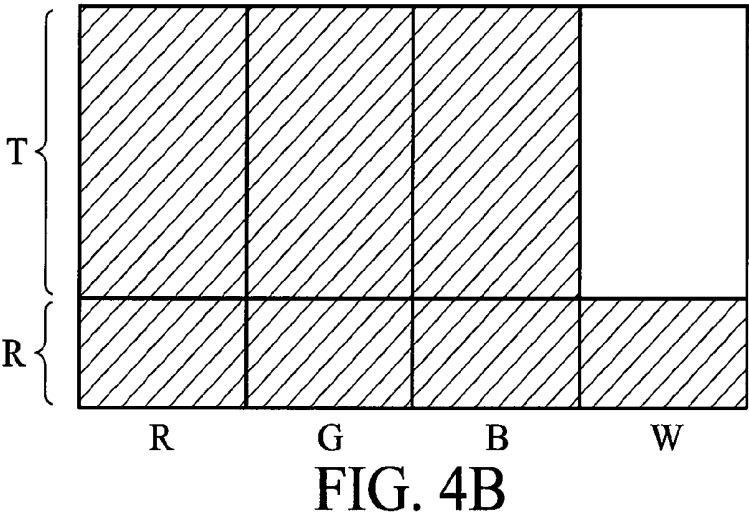
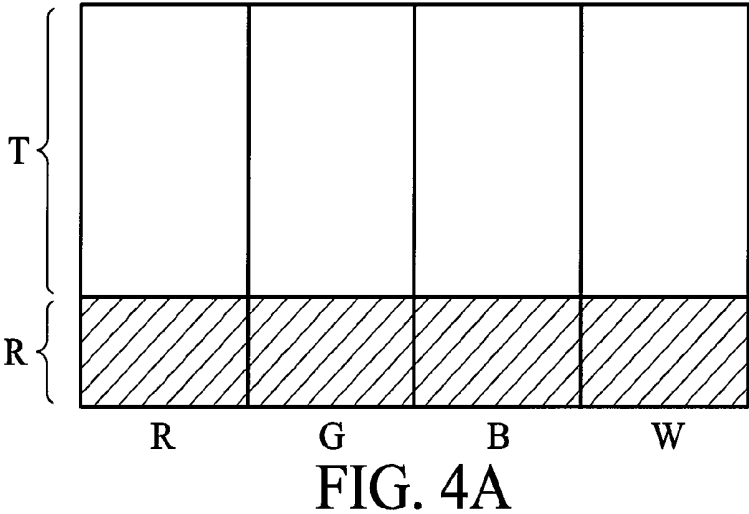


FIG. 3



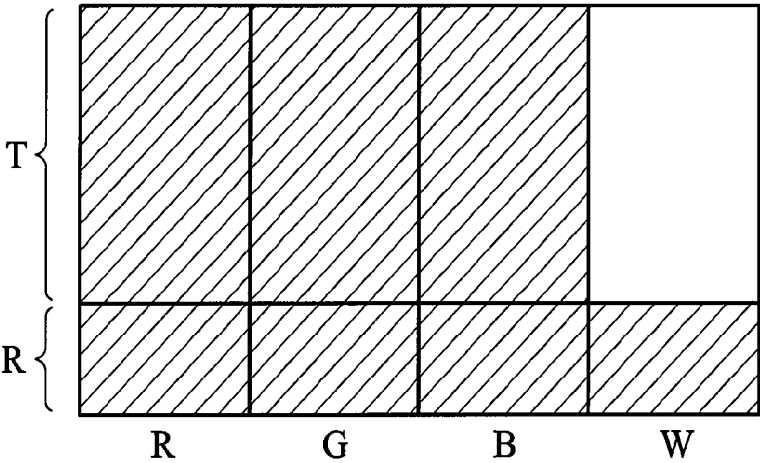


FIG. 5A

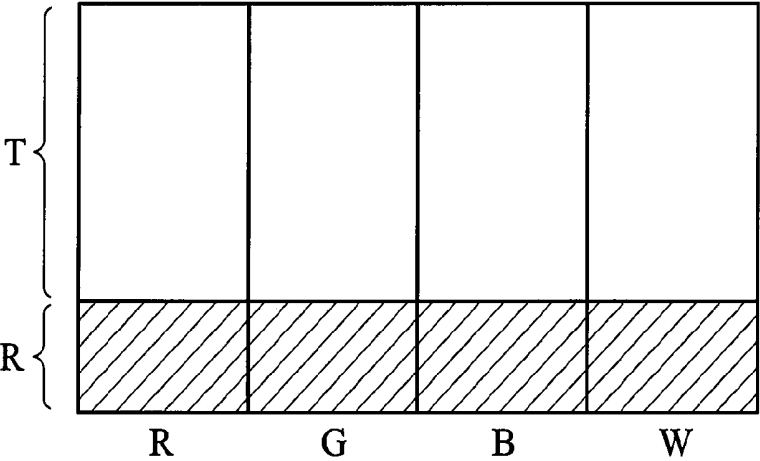


FIG. 5B

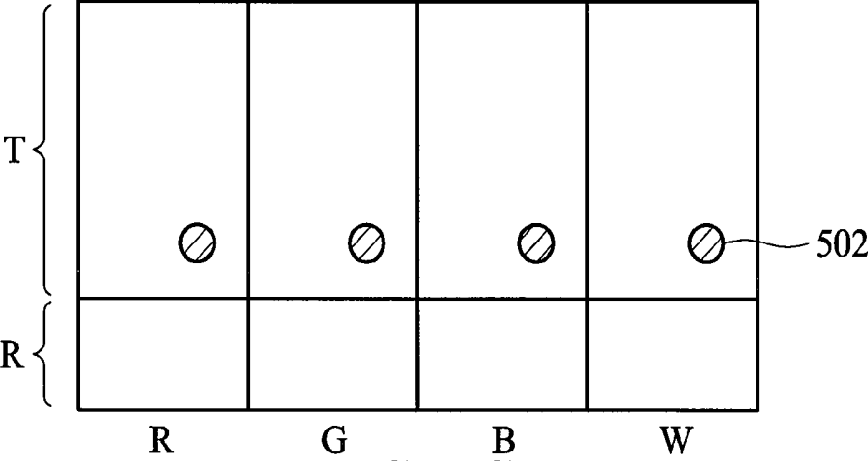


FIG. 5C

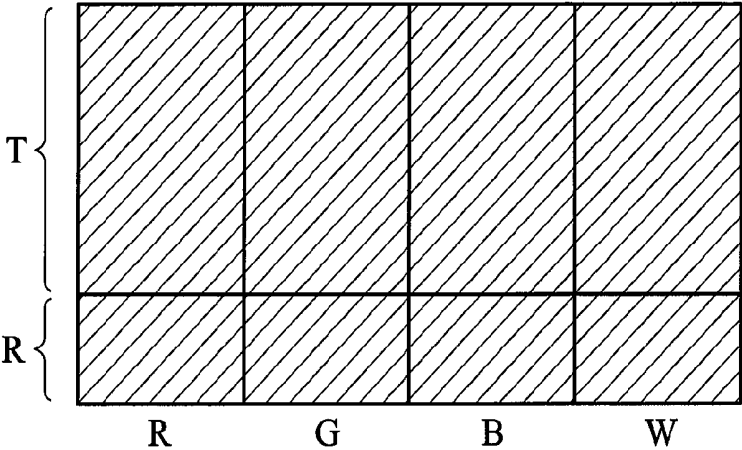


FIG. 6A

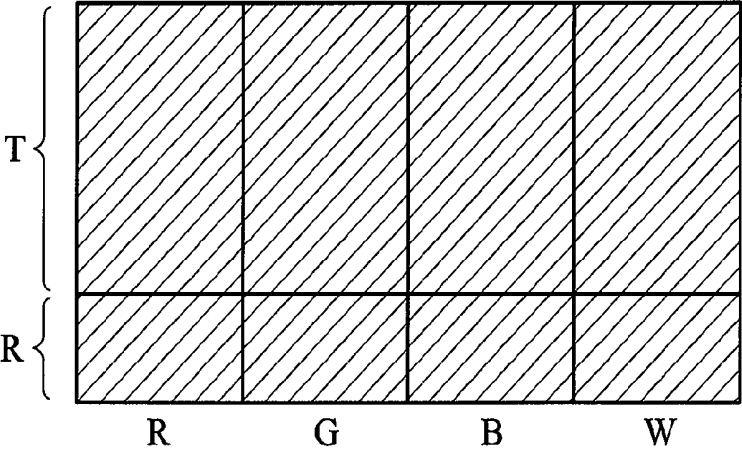


FIG. 6B

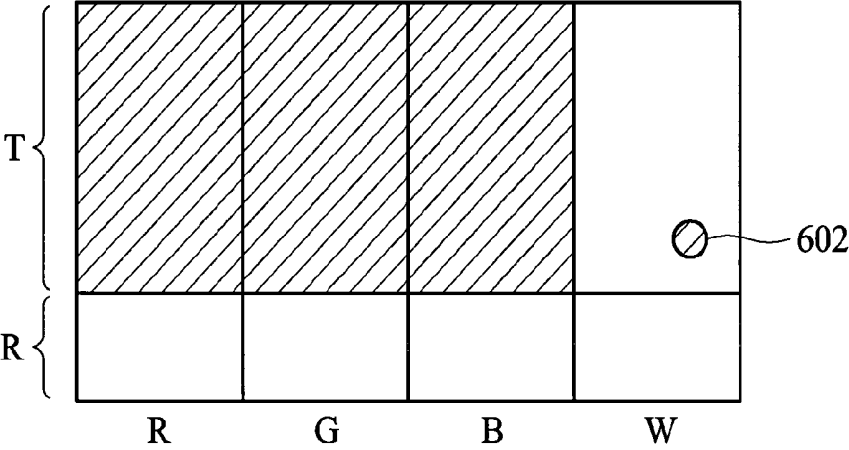


FIG. 6C

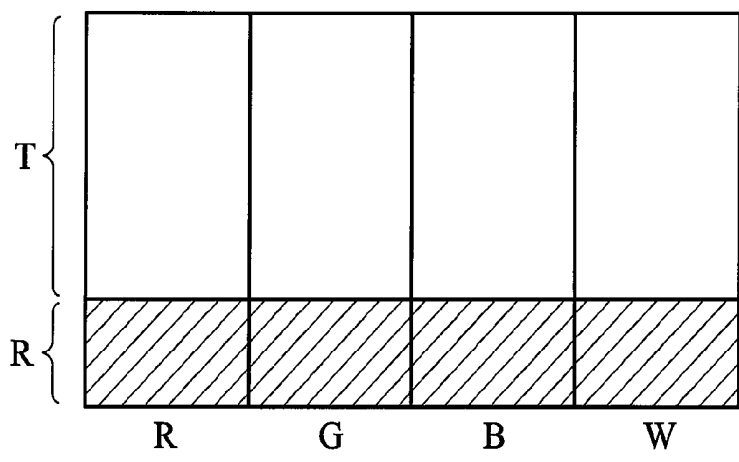


FIG. 7A

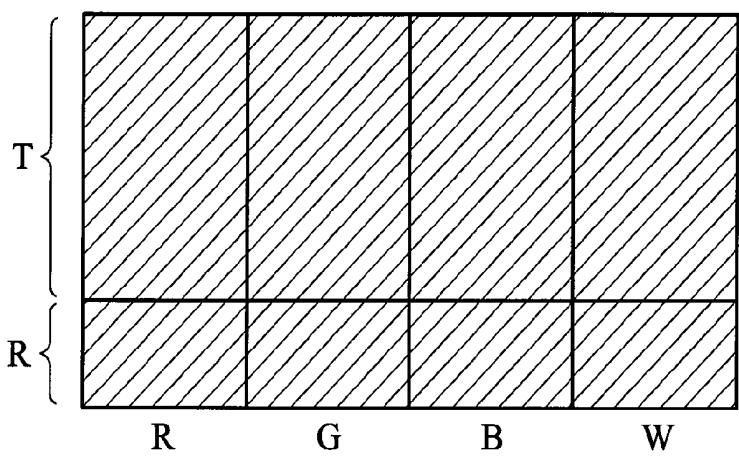


FIG. 7B

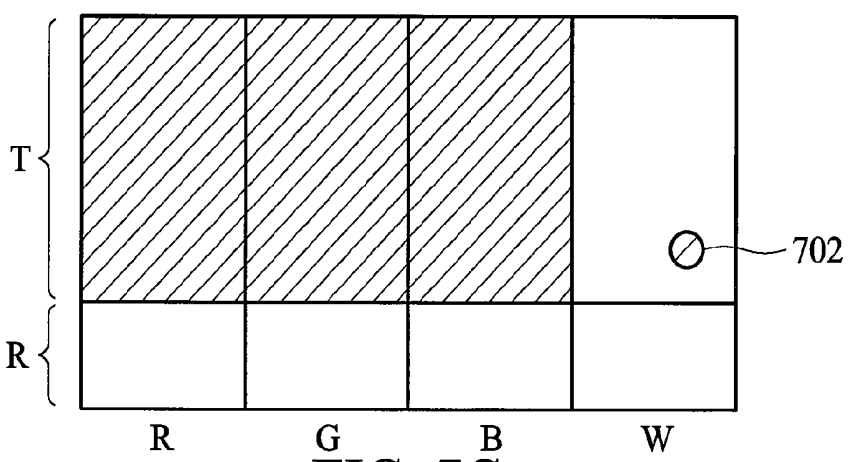


FIG. 7C

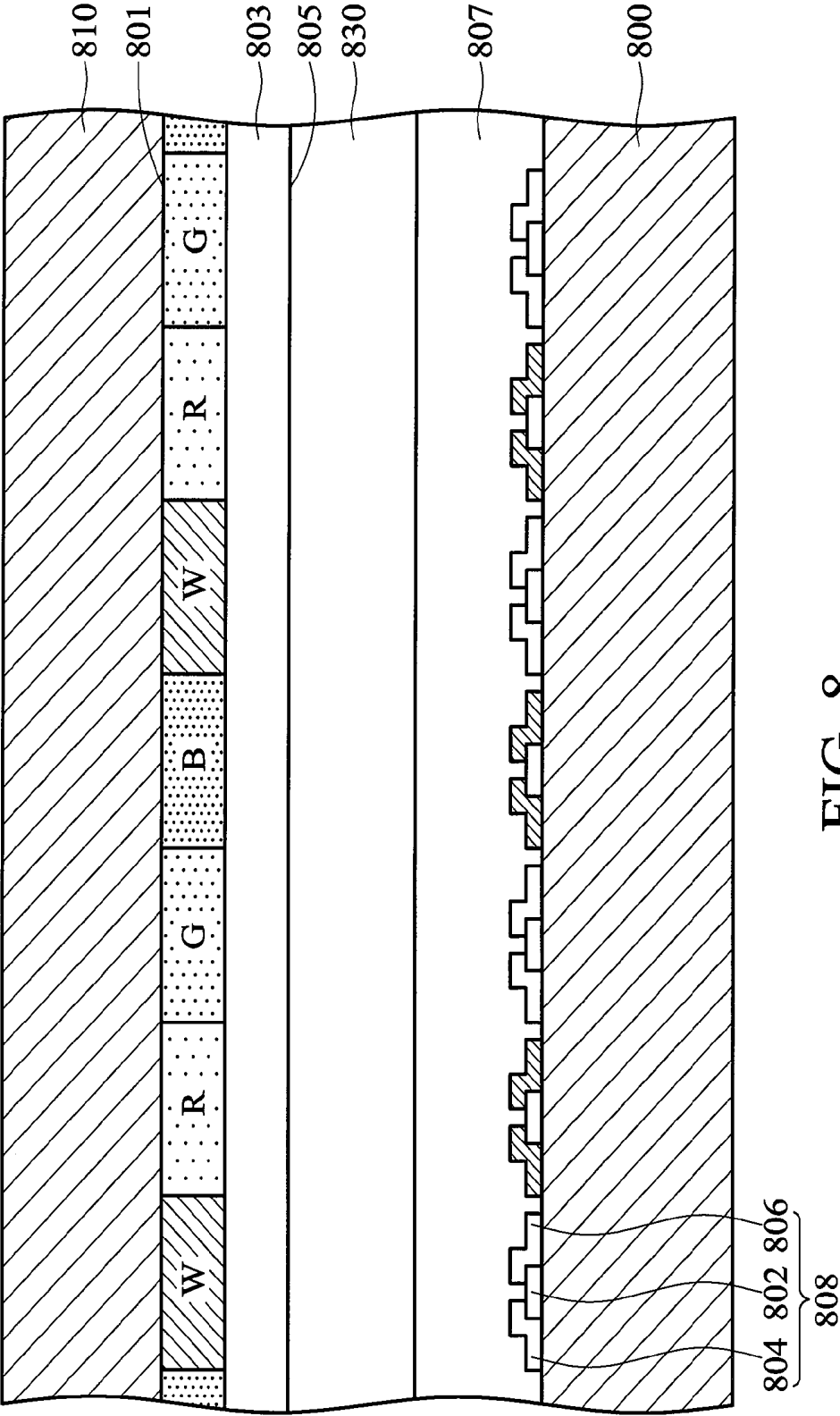


FIG. 8

TRANSFLECTIVE LIQUID CRYSTAL DISPLAYS AND METHODS FOR FABRICATING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a display and methods for fabricating the same, and more particularly, to a liquid crystal display and methods for fabricating the same.

[0003] 2. Description of the Related Art

[0004] Liquid crystal displays (LCD) are commonly used for flat panel displays. Owing to dielectric anisotropy and conductive anisotropy of liquid crystal molecules, molecular orientation of liquid crystals can be shifted under an external electronic field, such that various optical effects are produced. The panel structure of an LCD typically comprises two laminated substrates separated by a gap and liquid crystal injected therebetween. Corresponding electrodes on each substrate control the direction and arrangement of liquid crystal molecules.

[0005] Referring to FIG. 1A, in addition to the three primary colors pixels, which are red, green, and blue pixels, a white pixel is also provided to increase transmissive or reflective brightness and thus reduce power consumption. Mixed RGBW LCDs, however, suffer from many drawbacks.

[0006] Referring to FIG. 1B, a first substrate **100** such as an array substrate is provided. The first substrate **100** comprises a plurality of pixels, each comprising a plurality of sub-pixels.

[0007] A plurality of thin film transistors (TFTs) **108** is then formed on the first substrate **100**, and each sub-pixel corresponds to a TFT **108**. The TFT **108** comprises a gate **102**, source **104**, and drain **106**.

[0008] A second substrate **110** opposite to the first substrate **100** is provided. The second substrate **110**, preferably is a color filter substrate, comprises a red region provided with a red resist layer R thereon, a blue region provided with a blue resist layer B thereon, a green region provided with a green resist layer G thereon and a white region provided with a transparent resist layer W thereon, wherein each region corresponds to a sub-pixel. Thus, a color filter layer with the mixed RGBW is obtained.

[0009] After forming the RGB resist layers, a planarized covering layer **112** is blanketly coated on the second substrate **110** and the gaps between RGB resist layers is thus filled with the covering layer **112**, thereby forming the transparent resist layer W. The planarized covering layer **112** is beneficial for subsequent fabrication processes due to its planar surface. Because the RGB resist layers affect surface tension and mechanical action of the covering layer **112**, a gap "d" exists in portions of the covering layer **112** corresponding to the white region. Accordingly, a color shift phenomenon such as a yellow shift arises in LCDs.

BRIEF SUMMARY OF THE INVENTION

[0010] In accordance with one embodiment of the present invention, a transfective liquid crystal display comprises a first substrate comprising a plurality of pixels, wherein each pixel comprises a plurality of sub-pixels and each sub-pixel comprises at least one transmissive region and at least one reflective region. A second substrate is substantially opposite to the first substrate, wherein the second substrate is defined

into a plurality of regions corresponding to the sub-pixels, and at least three of the regions are color regions and at least one of the regions is a fourth region. A first covering layer covers the first substrate, wherein a portion of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least one fourth region is substantially thicker than other portions of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least three of the regions, and the thickness of the first covering layer in the reflective region of each sub-pixels corresponding to the at least one fourth region is substantially equal to the thickness of other portions of the first covering layer in the reflective region of each sub-pixels corresponding to the at least three of the regions. And a liquid crystal layer is disposed between the first substrate and the second substrate.

[0011] In accordance with another embodiment of the present invention, a method for forming a transfective liquid crystal display comprises providing a first substrate comprising a plurality of pixels, each pixel comprises a plurality of sub-pixels, and each sub-pixel comprises at least one transmissive region and at least one reflective region. A second substrate substantially opposite to the first substrate is provided, wherein the second substrate are defined into a plurality of regions corresponding to the sub-pixels, and at least three of the regions are color regions and at least one of the regions is a fourth region. A first covering layer is formed on the first substrate. A plurality of lithography processes are performed on the first covering layer, wherein number of exposures of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least one fourth region are less substantially than that of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least three of the regions, and a liquid crystal layer is interposed between the first substrate and the second substrate.

[0012] In accordance with yet another embodiment of the present invention, a method for fabricating a display comprises providing a first substrate comprising a plurality of pixels, each pixel comprises a plurality of sub pixels. A second substrate substantially opposite to the first substrate is provided, wherein the second substrate is defined into a plurality of regions corresponding to the sub-pixels, and at least three of the regions are color regions and at least one of the regions is a fourth region. A photoresist pattern layer is formed on the second substrate, wherein the photoresist pattern layer corresponding to the at least three color regions are color resist layers and the photoresist pattern layer corresponding to the at least one fourth region is a fourth resist layer. A first covering layer is formed on the photoresist pattern layer. And a liquid crystal layer is interposed between the first substrate and the second substrate.

[0013] A detailed description is given in the following embodiments with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The present invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

[0015] FIG. 1A is schematic view of pixel arrangement of a mixed RGBW LCD.

[0016] FIG. 1B is cross section of a conventional transfective liquid crystal display.

[0017] FIG. 2 is a cross section of an embodiment of a single gap transfective liquid crystal display of the present invention.

[0018] FIG. 3 is a cross section of an embodiment of a dual gap transfective liquid crystal display of the present invention.

[0019] FIG. 4A-4C are schematic views showing formation of the second covering layer of the single gap transfective liquid crystal display according with a preferred embodiment of the present invention.

[0020] FIGS. 5A-5C are schematic views showing formation of the second covering layer of the single gap transfective liquid crystal display according with another embodiment of the present invention.

[0021] FIGS. 6A-6C are schematic views showing formation of the covering layer of the dual gap transfective liquid crystal display according with a preferred embodiment of the present invention.

[0022] FIGS. 7A-7C are schematic views showing formation of the covering layer of the dual gap transfective liquid crystal display according with another embodiment of the present invention.

[0023] FIG. 8 is a cross section of a transfective liquid crystal display according with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] The following description is of the best-contemplated mode of carrying out the invention. This description is made for the purpose of illustrating the general principles of the present invention and should not be taken in a limiting sense. The scope of the present invention is best determined by reference to the appended claims.

[0025] In this specification, expressions such as “overlying the substrate”, “above the layer”, or “on the film” simply denote a relative positional relationship with respect to the surface of the base layer, regardless of the existence of intermediate layers. Accordingly, these expressions may indicate not only the direct contact of layers, but also, a non-contact state of one or more laminated layers.

[0026] FIG. 2 shows a cross section of a single gap transfective liquid crystal display according with a preferred embodiment of the present invention. Referring to FIG. 2, a first substrate 200, which the materials may comprise transparent material such as glass, low alkali glass, non-alkali glass, or likes, flexible material such as plastics, poly carbonate (PC), polymethyl methacrylate (PMMA), or likes, opaque material such as ceramics, wafer, or likes, is provided. The first substrate 200 comprises a plurality of pixels for displaying image, each comprising a plurality of sub-pixels. Each sub-pixel comprises at least a reflective region R and at least a transmissive region T. In the reflective region R, a light source for the liquid crystal display is provided by reflected exterior light, while in the transmissive region T, a back light source is used as a light source for the liquid crystal display. The transfective liquid crystal display thus reduces power consumption and achieves better efficiency.

[0027] A plurality of thin film transistors (TFTs) 208 are formed on the first substrate 200 which may be an array substrate. In a preferred embodiment, each sub-pixel corresponds to a TFT 208, and each TFT 208 comprises a gate 202, a channel (not shown), an ohmic contact layer (not shown), source 204, and drain 206. Preferably, the TFT 208

may be a bottom-gate type TFT, but not-limited it's. Of course, other types of TFTs such as a top-gate type TFT, an etching stop type TFT, or likes may be can to use. Constructing of the material of the TFT 208 may comprise polysilicon, amorphous silicon, single crystal silicon, microcrystalline silicon, or combinations thereof. In other words, the material of the channel (not shown) and the ohmic contact layer (not shown) may comprise polysilicon, amorphous silicon, single crystal silicon, microcrystalline silicon, or combinations thereof. The ohmic contact layer (not shown) may be doped with N type ions such as P, As, or the like. Alternatively, the ohmic contact layer (not shown) may be doped with P type ions such as B or the like.

[0028] A second substrate 210 substantially opposite to the first substrate 200 is provided. The second substrate 210, preferably a color filter substrate, may comprise at least three color regions and at least one fourth region corresponding to the sub-pixels. These three color regions may comprise a red region provided with a red resist layer R thereon, a blue region provided with a blue resist layer B thereon and a green region provided with a green resist layer G thereon. The fourth region may comprise a white region, also referred to as an achromatic region, provided with a transparent resist layer W thereon. A color filter layer with the mixed RGBW is thus obtained.

[0029] The embodiments of the present invention described hereinafter are based on the three primary colors RGB as shown in FIG. 2. The present invention is, however, not limited to the disclosed RGB regions. In other words, various colors of resist layers in the color regions, for example, yellow, brown, purple, or other colors can be used without departing from the spirit or scope of the present inventive concept. Additionally, the embodiments of the present invention are based on a rectangular shape of the color regions and the fourth region. The present invention is, however, not limited to the rectangular color regions or the fourth region disclosed. Various shapes of the color regions and the fourth region can be used, for example, circle, polygon, triangle, hexagon, or ellipse without departing from the spirit or scope of the present inventive concept. Furthermore, the present invention is not limited to the white region in the fourth region. Other colors of the resist layer or the colors of the resist layer can be used in the fourth region for improving color saturation and color contrast of an LCD.

[0030] In the above-mentioned LCD structure, a flatness of a covering layer 212 is blanketly coated on the second substrate 210 after forming the RGB resist layers, and the gaps between RGB resist layers is thus filled with the covering layer 212, thereby forming the transparent resist layer W. The covering layer 212 is beneficial to subsequent fabrication processes due to its planar surface. Because the RGB resist layers affect surface tension and mechanical action of the covering layer 212, a gap “d” exists in portions of the covering layer 212 corresponding to the fourth region.

[0031] In a preferred embodiment, a covering layer 214 is formed on the first substrate 200 to cover the first substrate 200 and the TFTs 208. In the transmissive region T, a portion of the covering layer 214 corresponding to the fourth region (white region) is substantially thicker than other portions of the covering layer 214 corresponding to the color regions. In the reflective region R, a portion of the covering layer 214 corresponding to the fourth region (white region) and the color regions has substantially uniform thickness. In other

words, the covering layer **214** corresponding to the transmissive region T of the fourth region has a protruding portion **216**. The protruding portion **216** of the covering layer **214** compensates for the gap “d” in the covering layer **212** corresponding to the white region, and optical efficiency of a display is thus improved.

[0032] Detailed description of forming the aforementioned structure of the covering layer **214** is provided in the following. The covering layer **214**, preferably comprising photo-sensitive material, is formed on the first substrate **200**. The covering layer **214** is exposed for a plurality of times, wherein the number of exposures of the covering layer **214** corresponding to the white region in the transmissive region T is less than that of the covering layer **214** corresponding to the red, blue, and green regions in the transmissive region T. The covering layer **214** is then developed.

[0033] FIG. 4A-4B are schematic views showing formation of the covering layer **214** of the single gap transfective liquid crystal display according with a preferred embodiment of the present invention. Referring to FIG. 4A, the covering layer **214**, which may comprise photo-sensitive material such as photoresist, is blanketly coated on the first substrate (not shown) to cover the thin film transistors (not shown) and the first substrate. In a preferred embodiment, the photoresist layer acting as the covering layer is a positive photoresist layer. The covering layer **214** corresponding to the reflective region T is exposed, while the covering layer **214** corresponding to the transmissive region T is shaded by a mask such as a photomask. The exposed portion of the covering layer **214** is marked by oblique lines.

[0034] Referring to FIG. 4B, the covering layer **214** corresponding to the transmissive region T of the fourth region (white region) is shaded by, for example, a photomask, while the covering layer **214** corresponding to the transmissive region T of the RGB regions and the covering layer **214** corresponding to the reflective region R are exposed. Referring to 4C, the covering layer **214** besides openings **402** in the transmissive region T is shaded by, for example, a photomask, while the covering layer **214** corresponding to the opening segments in the transmissive region T is exposed. In the light of the previously described method for performing lithography processes on the covering layer **214**, the number of exposures of the covering layer **214** in the transmissive region of each sub-pixels corresponding to the at least one fourth region is less than that of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least three of the regions for once. Accordingly, the covering layer **214** corresponding to the transmissive region of the fourth region is substantially thicker than the covering layer **214** corresponding to the transmissive region T of the RGB regions.

[0035] In a preferred embodiment, the covering layer **214** may have a thickness of about 2.0 μm . Exposure doses may expose the covering layer **214**, made of positive photoresist, to a depth of about 0.6 μm to about 0.8 μm . The covering layer **214** corresponding to the transmissive region T of the white region may have a thickness of about 1.8 μm to about 2.2 μm . The covering layer **214** corresponding to other portions besides the transmissive region T of the white region may have a thickness of about 1 μm to about 1.6 μm , preferably, 1.2 μm to about 1.6 μm . The protruding portion **216** may has a thickness of about 0.1 μm to about 0.3 μm , that is, the portion of the covering layer **214** in the transmissive region of each sub-pixels corresponding to the at

least one fourth region is thicker than the other portions of the covering layer **214** in the transmissive region of each sub-pixels corresponding to the at least three of the regions about 0.1 μm to about 0.3 μm .

[0036] FIGS. 5A-5C are schematic views showing formation of the covering layer **214** of the single gap transfective liquid crystal display according with another embodiment of the present invention. Referring to FIG. 5A, the covering layer **214**, which may comprise photo-sensitive material such as photoresist, is blanketly coated on the first substrate (not shown) to cover the thin film transistors (not shown) and the first substrate. In a preferred embodiment, the photoresist layer acting as the covering layer **214** is a positive photoresist layer. The covering layer **214** corresponding to the transmissive region T of the fourth region is shaded by, for example, a photomask, while the covering layer **214** corresponding to the transmissive region T of the RGB regions and the covering layer **214** corresponding to the reflective region R are exposed.

[0037] Referring to FIG. 5B, the covering layer **214** corresponding to the transmissive region T is shaded by, for example, a photomask, while the covering layer **214** corresponding to the reflective region R is exposed. Referring to FIG. 5C, the covering layer **214** besides openings **502** in the transmissive region T is shaded by, for example, a photomask, while the covering layer **214** corresponding to the openings **502** in the transmissive region T is exposed. In the light of the previously described method for performing lithography process on the covering layer **214**, the number of exposures of the covering layer **214** in the transmissive region of each sub-pixels corresponding to the at least one fourth region is less than that of the covering layer **214** in the transmissive region of each sub-pixels corresponding to the at least three of the regions for once. Accordingly, the covering layer **214** corresponding to the transmissive region of the fourth region is substantially thicker than the covering layer **214** corresponding to the transmissive region T of the RGB regions.

[0038] FIG. 3 shows a cross section of a dual gap transfective liquid crystal display according with a preferred embodiment of the invention. The structure and fabrication process of FIG. 3 is similar to FIG. 2. Therefore, detailed description thereof is omitted. FIG. 3 differs from FIG. 2 in that a thickness T_r of a liquid crystal layer **302** in a reflective region R is substantially less than a thickness T_t of the liquid crystal layer **302** in a transmissive region T. Accordingly, the covering layer **304** corresponding to the reflective region R is substantially thicker than the covering layer **304** corresponding to the transmissive region T. To reduce the color shift phenomenon, the covering layer **304** corresponding to the fourth region (white region) in the transmissive region T is substantially thicker than the covering layer **304** corresponding to the RGB regions in the transmissive region T. In the reflective region R, a portion of the covering layer **304** corresponding to the fourth region (white region) and the color regions (RGB) has substantially uniform thickness. In a word, the covering layer corresponding to the white region in the transmissive region T has a protruding portion **306**.

[0039] Detailed description of forming the aforementioned structure of the covering layer **214** is provided in the following. The covering layer **304**, preferably comprising photo-sensitive material, is formed on the first substrate. The covering layer **304** is then exposed for a plurality of times, wherein the number of exposures of the covering layer **304**

in the transmissive region T is more than that of the covering layer 304 in the reflective region R, and the number of exposures of the covering layer 304 corresponding to the white region in the transmissive region T is less than that of the covering layer 304 corresponding to the RGB regions in the transmissive region T. The covering layer 304 is next developed.

[0040] FIGS. 6A-6C are schematic views showing formation of the covering layer 304 of the dual gap transfective liquid crystal display according with a preferred embodiment of the invention. Referring to FIG. 6A, the covering layer 304, which may comprise photo-sensitive material such as photoresist, is blankedly coated on the first substrate (not shown) to cover the thin film transistors (not shown) and the first substrate. In a preferred embodiment, the photoresist layer acting as the covering layer 304 is a positive photoresist layer. The entire covering layer 304 is exposed. The exposed portion of the covering layer 304 is marked by oblique lines.

[0041] Referring to FIG. 6B, the entire covering layer 304 is then exposed again. Referring to 6C, the covering layer 304 corresponding to the RGB regions in the transmissive region T and the covering layer 304 corresponding to an opening 602 of the white region in the transmissive region T are exposed, while the covering layer 304 except for the opening 602 in the transmissive region T and the covering layer 304 corresponding to the RGB regions and white region in the reflective region R are shaded by, for example, a photomask. In the light of the previously described method for performing lithography processes on the covering layer 304, the number of exposures of the covering layer 304 in the transmissive region of each sub-pixels corresponding to the at least one fourth region (white region) is less than that of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least three of the regions (RGB regions) for once. Accordingly, the covering layer 304 corresponding to the transmissive region of the white region is substantially thicker than the covering layer 304 corresponding to the transmissive region T of the RGB regions.

[0042] FIGS. 7A-7C are schematic views showing formation of the covering layer 304 of the dual gap transfective liquid crystal display according with another embodiment of the invention. Referring to FIG. 6A, the covering layer 304, which may comprise photo-sensitive material such as photoresist, is blankedly coated on the first substrate (not shown) to cover the thin film transistors (not shown) and the first substrate. In a preferred embodiment, the photoresist layer acting as the covering layer 304 is a positive photoresist layer. The covering layer 304 in the reflective region R is exposed, while the covering layer 304 in the transmissive region T is shaded by, for example, a photomask.

[0043] Referring FIG. 7B, the entire covering layer 304 is exposed. Referring to 7C, the covering layer 304 corresponding to the RGB regions in the transmissive region T and the covering layer 304 corresponding to an opening 702 of the white region in the transmissive region T are exposed, while the covering layer 304 except for the opening 702 in the transmissive region T and the covering layer 304 corresponding to the RGB regions and white region in the reflective region R are shaded by, for example, a photomask. In the light of the previously described method for performing lithography process on the covering layer 304, the number of exposures of the covering layer 304 in the transmissive region of each sub-pixels corresponding to the

at least one fourth region (white region) is less than that of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least three of the regions (RGB regions) for once. Accordingly, the covering layer 304 corresponding to the transmissive region of the white region is substantially thicker than the covering layer 304 corresponding to the transmissive region T of the RGB regions.

[0044] FIG. 8 is a cross section of a transfective liquid crystal display according with another embodiment of the invention. Referring to FIG. 8, a first substrate 800, which may comprise transparent material such as glass, low alkali glass, non-alkali glass, or likes, flexible material such as plastics, poly carbonate (PC), polymethyl methacrylate (PMMA), or likes, opaque material such as ceramic, wafer, or likes, is provided. The first substrate 800 comprises a plurality of pixels.

[0045] A plurality of thin film transistors (TFTs) 808 are formed on the first substrate 800 which may be an array substrate. In a preferred embodiment, each sub-pixel corresponds to a TFT 808, and each TFT 808 comprises a gate 802, a channel (not shown), an ohmic contact layer (not shown), source 804 and drain 806. Preferably, the TFT 808 may be a bottom-gate type TFT. Alternatively, other types of TFTs such as a top-gate type TFT, an etching stop type TFT, or likes may be used. The TFT 808 may be made of polysilicon, amorphous silicon, single crystal silicon, microcrystalline silicon, or combinations thereof. The channel (not shown) and the ohmic contact layer (not shown) may comprise polysilicon, amorphous silicon, single crystal silicon, microcrystalline silicon, or combinations thereof. The ohmic contact layer (not shown) may be doped with N type ions such as P, As, or likes. Alternatively, the ohmic contact layer (not shown) may be doped with P type ions such as B or likes. A first covering layer 807 is then formed on the first substrate 800 and TFTs 808.

[0046] A second substrate 810 opposite to the first substrate 800 is provided. The second substrate 810, preferably a color filter substrate, may comprise at least three color regions and one fourth region corresponding to the sub-pixels. These three color regions may comprise a red region, a blue region, and a green region, and the fourth region may comprise a white region. Photoresist pattern layers are then formed on the second substrate 810. The photoresist pattern layers comprises a red resist layer R in the red region, a blue resist pattern layer B in the blue region, a green resist pattern layer G in the green and a transparent resist pattern layer W in the white region. In a preferred embodiment, the red resist pattern layer R is formed in the red region in the second substrate 810 by a lithography process. The blue resist pattern layer B is formed in the blue region in the second substrate 810 by a lithography process. The green resist pattern layer G is formed in the green region in the second substrate 810 by using a lithography process. The transparent resist pattern layer W is formed in the white region in the second substrate 810 by using a lithography process.

[0047] Note that the transparent resist pattern layer W is filled into the fourth region in the second substrate 810, and the transparent W in the color regions such as RGB regions is removed by a lithography process. Because the transparent resist pattern layer W only exists in the white region, a gap "d" in portions of the covering layer on the second substrate 810 corresponding to the white region due to the surface tension and the mechanical action of the RGB region thus disappears.

[0048] A covering layer 803 is then formed in the RGB regions and white region on the second substrate 810. Surface of the covering layer 803 is flat, and there is no gap “d” in the covering layer 803. Lastly, a liquid crystal layer 830 is interposed between the first substrate 800 and the second substrate 810 to complete the fabrication of an LCD.

[0049] According to the disclosed embodiments above, in a single gap transfective liquid crystal display or a dual gap transfective liquid crystal display, the covering layer corresponding to the white region is substantially thicker than the covering layer corresponding to the color regions by adjusting the number of exposures of the covering layer in the transmissive region. While, the covering layer corresponding to the reflective region substantially has a uniform thickness. In the reflective region, a circuit controller such as a Look-Up-Table may be used to reduce the color shift phenomenon, for example yellow shift.

[0050] Accordingly, embodiments of the present invention provide methods for fabricating a liquid crystal display, which improve optical efficiency of an LCD by eliminating the gap causing the color shift phenomenon in the white region.

[0051] While the present invention has been described by way of example and in terms of the preferred embodiments, it is to be understood that the present invention is not limited to the disclosed embodiments. To the contrary, it is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in the art). Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

What is claimed is:

1. A transfective liquid crystal display, comprising:
 - a first substrate comprising a plurality of pixels, each pixel comprises a plurality of sub-pixels, wherein each sub-pixel comprises at least one transmissive region and at least one reflective region;
 - a second substrate substantially opposite to the first substrate, wherein the second substrate is divided into a plurality of regions corresponding to the sub-pixels, and at least three of the regions are color regions and at least one of the regions is a fourth region;
 - a first covering layer covering the first substrate, wherein a portion of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least one fourth region is substantially thicker than other portions of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least three of the regions, and the thickness of the first covering layer in the reflective region of each sub-pixels corresponding to the at least one fourth region is substantially equal to the thickness of other portions of the first covering layer in the reflective region of each sub-pixels corresponding to the at least three of the regions; and
 - a liquid crystal layer disposed between the first substrate and the second substrate.
2. The transfective liquid crystal display of claim 1, wherein the portion of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least one fourth region is thicker than the other portions of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least three of the regions about 0.1 μm to about 0.3 μm .

3. The transfective liquid crystal display of claim 1, wherein the first covering layer comprises photo-sensitive material.

4. The transfective liquid crystal display of claim 1, further comprising:

- a second covering layer covering the second substrate, wherein the second covering layer in the fourth region is substantially thinner than the second covering layer in the color regions.

5. A method for forming a transfective liquid crystal display, comprising:

- providing a first substrate comprising a plurality of pixels, each pixel comprises a plurality of sub-pixels and each sub-pixel comprises at least one transmissive region and at least one reflective region;

- providing a second substrate substantially opposite to the first substrate, wherein the second substrate are divided into a plurality of regions corresponding to the sub-pixels, and at least three of the regions are color regions and at least one of the regions is a fourth region;

- forming a first covering layer on the first substrate;

- performing a plurality of lithographies on the first covering layer, wherein the number of exposures of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least one fourth region are less than that of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least three of the regions; and

- interposing a liquid crystal layer between the first substrate and the second substrate.

6. The method of claim 5, wherein the first covering layer comprises photo-sensitive material.

7. The method of claim 5, wherein the number of exposures of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least one fourth region is less than that of the first covering layer in the transmissive region of each sub-pixels corresponding to the at least three of the color regions for once.

8. The method of claim 5, wherein performing the lithographies on the first covering layer comprises:

- exposing the first covering layer in the reflective region of each pixels corresponding to the at least three color regions and the at least one fourth region;

- exposing the first covering layer in the transmissive region of each pixels corresponding to the at least three color regions and the first covering layer in the reflective region of each pixels corresponding to the least three color regions and the at least one fourth region without exposing the first covering layer in the transmissive region of each pixels corresponding to the at least one fourth region;

- exposing the portion of the first covering layer in the transmissive region of each pixels corresponding to the at least three color regions and the at least one fourth region to form at least one opening segment; and
- developing the first covering layer.

9. The method of claim 5, wherein performing the lithographies on the first covering layer comprises:

- exposing the first covering layer in the transmissive region of each pixels corresponding to the at least three color regions and the first covering layer the reflective region of each pixels corresponding to at least three the color regions and the at least one fourth region without

exposing the first covering layer in the transmissive region of each pixels corresponding to the at least one fourth region;

exposing the first covering layer in the reflective region of each pixels corresponding to the at least three color regions and the at least one fourth region;

exposing the portion of the first covering layer in the transmissive region of each pixels corresponding to the at least three color regions and the at least one fourth region to form at least one opening segment; and developing the first covering layer.

10. The method of claim 5, wherein performing the lithographies on the first covering layer comprises:

exposing the first covering layer in the transmissive region and the reflective region of each pixels corresponding to the at least three color regions and the first covering layer in the transmissive region and the reflective region of each pixels corresponding to the at least one fourth region;

exposing the first covering layer in the transmissive region and the reflective region of each pixels corresponding to the at least three color regions and the first covering layer in the transmissive region and the reflective region of each pixels corresponding to the at least one fourth region again;

exposing the portion of the first covering layer in the transmissive region of each pixels corresponding to the at least three color regions and the at least one fourth region to form at least one opening segment; and developing the first covering layer.

11. The method for forming a transfective liquid crystal display of claim 5, wherein performing the lithographies on the first covering layer comprises:

exposing the first covering layer in the reflective region of each pixels corresponding to the at least three color regions and the at least one fourth region;

exposing the first covering layer in the reflective region and the transmissive region of each pixels corresponding to the at least three color regions and the first covering layer in the reflective region and the transmissive region of each pixels corresponding to the fourth region;

exposing the portion of the first covering layer in transmissive region of each pixels corresponding to the at least three color regions and the at least one fourth region to form at least one opening segment; and developing the first covering layer.

12. The method of claim 5, further comprising:

forming a second covering layer on the second substrate, such that the second covering layer corresponding to the fourth region is substantially thinner than the second covering layer corresponding to the at least three color regions.

13. A method for fabricating a display comprising:

providing a first substrate comprising a plurality of pixels, each pixel comprises a plurality of sub pixels;

providing a second substrate substantially opposite to the first substrate, wherein the second substrate is divided into a plurality of regions corresponding to the subpixels, and at least three of the regions are color regions and at least one of the regions is a fourth region;

forming a photoresist pattern layer on the second substrate, such that the photoresist pattern layer corresponding to the at least three color regions are color photoresist pattern layers and the photoresist pattern layer corresponding to the at least one fourth region is a fourth photoresist pattern layer;

forming a first covering layer on the photoresist layer; and interposing a liquid crystal layer between the first substrate and the second substrate.

14. The method of claim 13, wherein the first covering layer has a substantially uniform thickness.

15. The method of claim 13, further comprising:

forming a second covering layer on the first substrate.

16. The method of claim 15, wherein the second covering layer has a substantially uniform thickness.

17. The method of claim 15, wherein the first covering layer and the second covering layer both have substantially uniform thicknesses.

18. The method for fabricating a display of claim 13, wherein the photoresist pattern layer has a substantially uniform thickness.

19. The method of claim 13, wherein formation the photoresist pattern layer comprises:

coating the photoresist layer on the second substrate; and patterning the photoresist layer to define the photoresist layer corresponding to the at least three color regions as the color resist pattern layers and to define the photoresist layer corresponding to the at least one fourth region as the fourth resist pattern layer.

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专利名称(译)	透反液晶显示器及其制造方法		
公开(公告)号	US20070247572A1	公开(公告)日	2007-10-25
申请号	US11/554657	申请日	2006-10-31
[标]申请(专利权)人(译)	友达光电股份有限公司		
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IPC分类号	G02F1/1335		
CPC分类号	G02F1/133516 G02F2202/023 G02F2001/133519 G02F1/133555		
优先权	095114273 2006-04-21 TW		
其他公开文献	US7545467		
外部链接	Espacenet USPTO		

摘要(译)

透反液晶显示器。第一基板包括多个像素，每个像素包括多个子像素，并且每个子像素包括至少一个透射区域和至少一个反射区域。第二基板与第一基板相对，分成对应于子像素的多个区域，并且至少三个区域是颜色区域，并且至少一个区域是第四区域。第一覆盖层覆盖第一基板，其中对应于第四区域的透射区域中的第一覆盖层基本上厚于对应于三个颜色区域的第一覆盖层，并且对应于第四区域的反射区域中的第一覆盖层具有厚度基本上等于对应于三个颜色区域的厚度。液晶层设置在第一和第二基板之间。

