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Wu

(54) **TRANSFLECTIVE LIQUID CRYSTAL DISPLAY PANEL**

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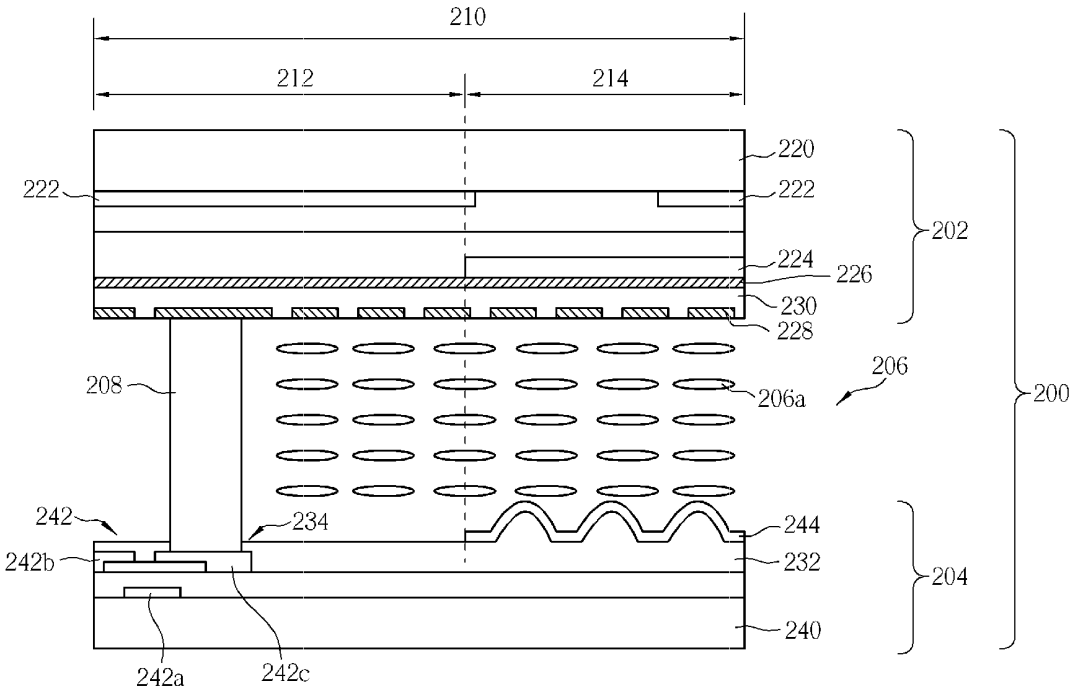
(52) **U.S. Cl.** **349/43**

(57) **ABSTRACT**

A transflective liquid crystal display panel includes a color filter substrate and a thin film transistor array substrate having a transmissive region and a reflective region defined thereon, a liquid crystal layer positioned between the CF substrate and the TFT array substrate, and at least a conductive spacer positioned in between the CF substrate and the TFT array substrate. The CF substrate includes a color filter array, at least a pixel electrode and a common electrode positioned between the pixel electrode and the CF array. The common electrode is electrically isolated from the pixel electrode. The TFT array substrate includes at least a TFT having a gate, a source and a drain positioned in the transmissive region, and at least a reflector positioned in the reflective region. The conductive spacer electrically connects the pixel electrode positioned on the CF substrate to the drain positioned on the TFT array substrate.



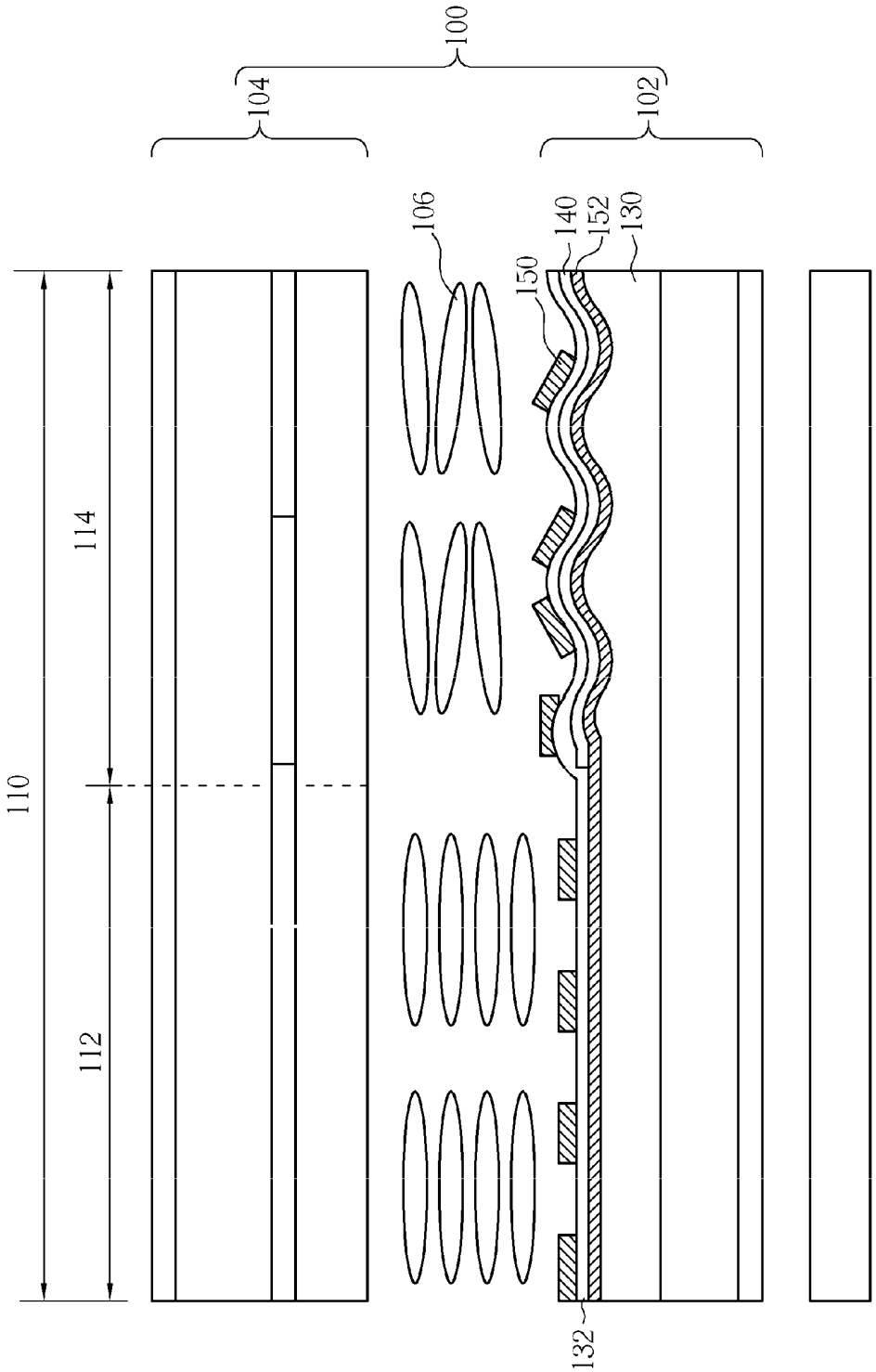


FIG. 1 PRIOR ART

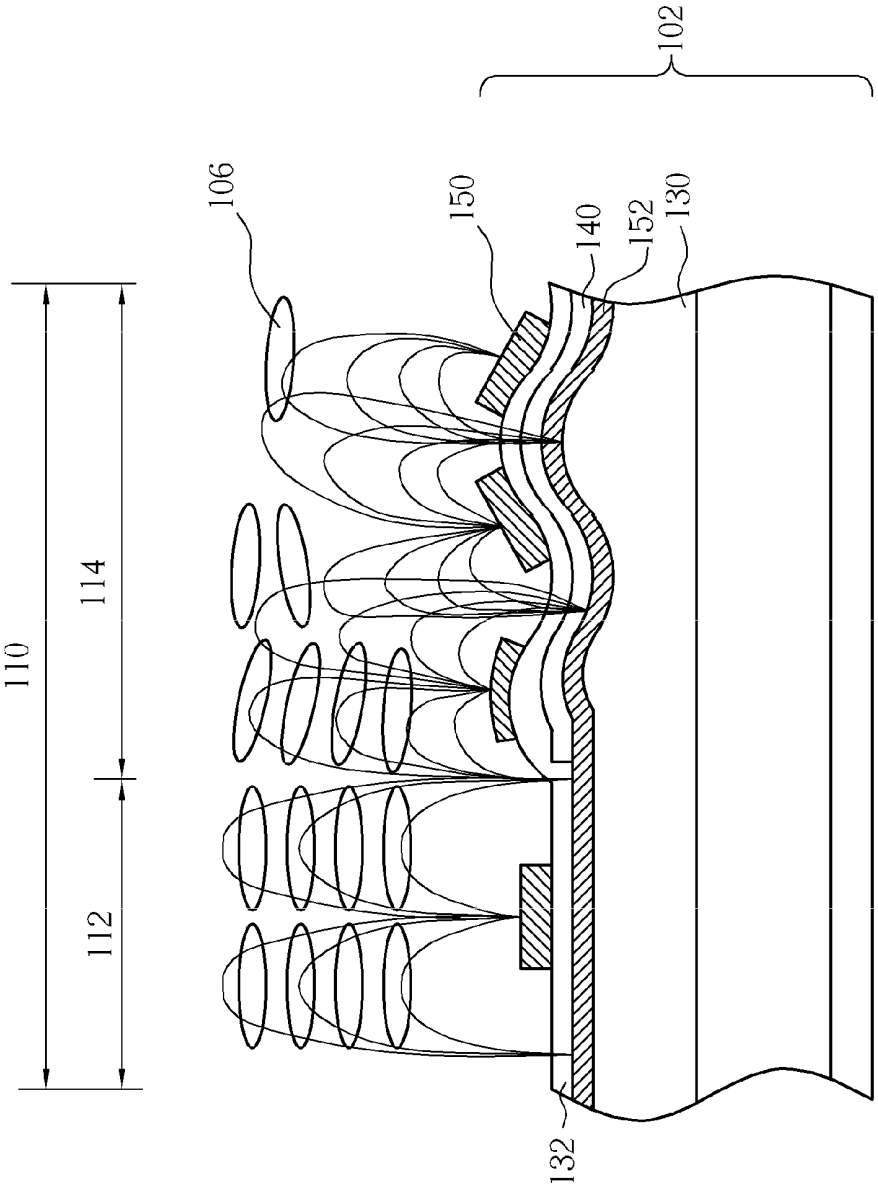


FIG. 2 PRIOR ART

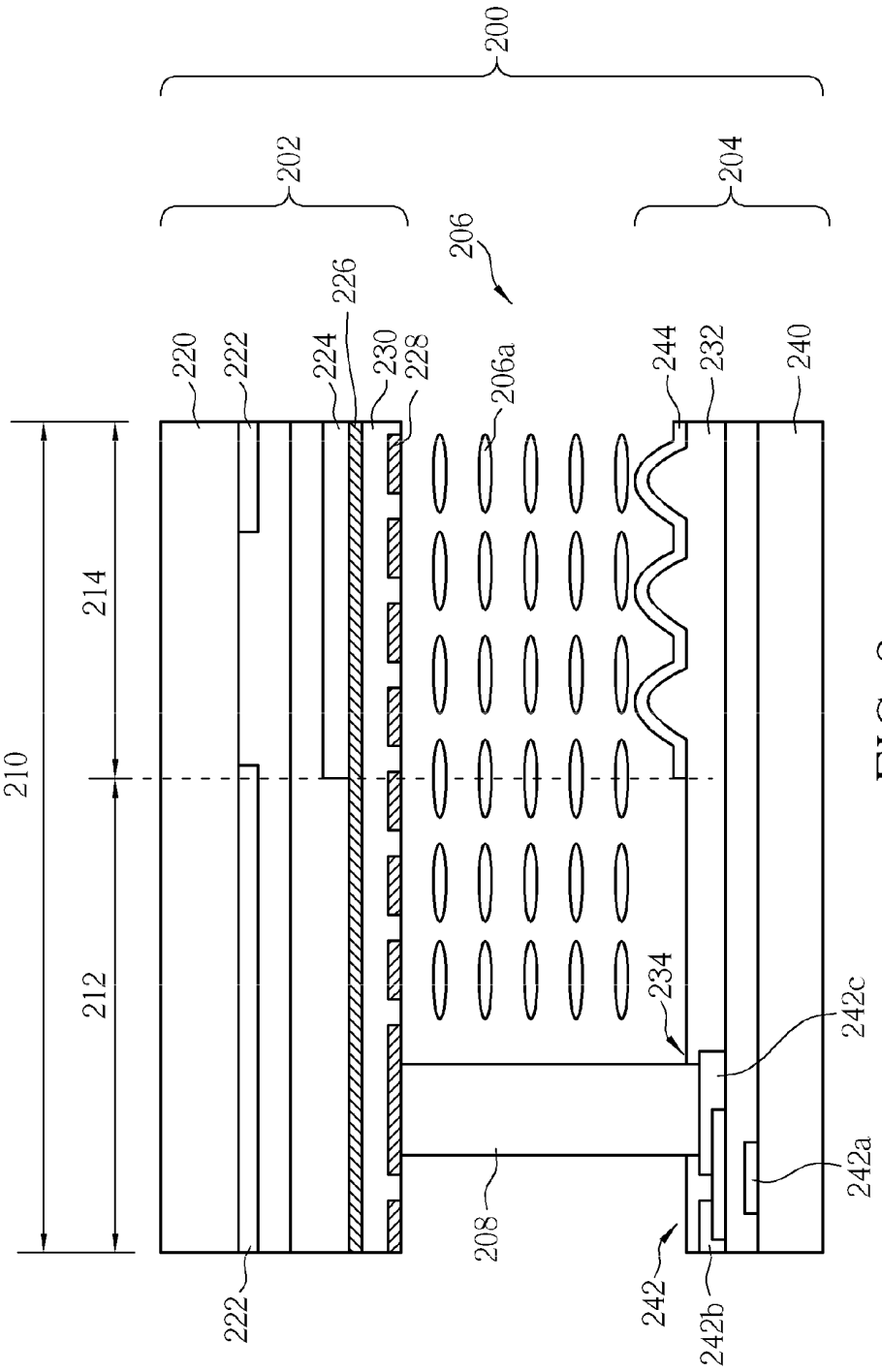

200
202
204
206
220
222
224
226
228
230
206a
232
240
244
210
214
212
234
242c
242a
208
222
242
242b

FIG. 3

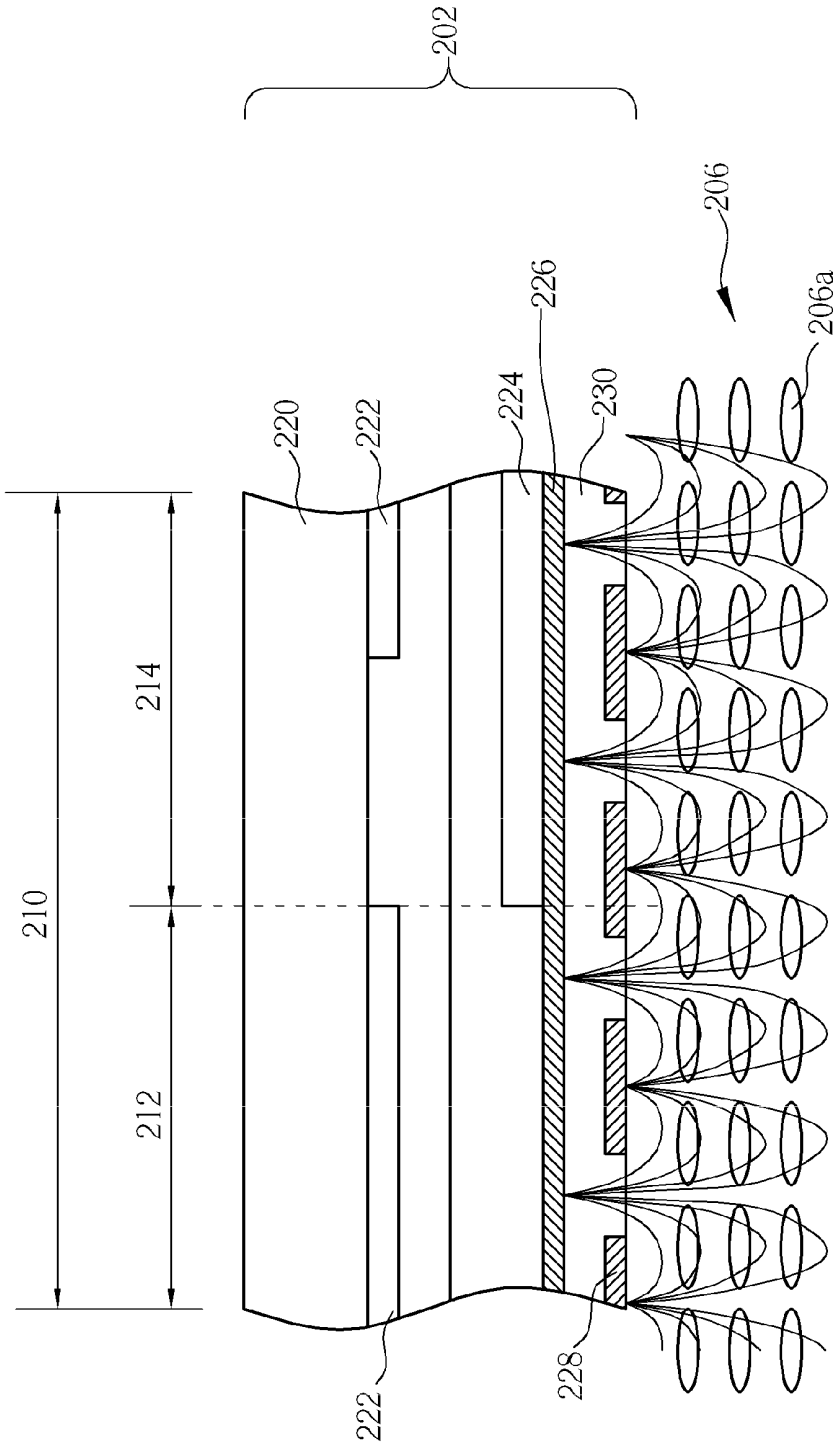


FIG. 4

TRANSFLECTIVE LIQUID CRYSTAL DISPLAY PANEL

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention is related to a transflective liquid crystal display (LCD), and more particularly, to a transflective in-plane switching (IPS) LCD.

[0003] 2. Description of the Prior Art

[0004] LCDs can be classified into transmissive, reflective, and transflective based on the source of illumination. Along with the popularization of portable electronic products, the LCDs have to give consideration to the brightness of indoor ambient light and that of outdoor ambient light, which are different greatly from each other. Therefore the transflective LCD panel is developed to provide superior performance in abovementioned different environments.

[0005] Furthermore, it is well-known that the alignment direction of the liquid crystal (LC) molecules can be controlled by applying electric fields to the LC molecules. Therefore, LCDs also can be classified into twisted nematic (TN) mode, vertical alignment (VA) mode, and in-plane switching (IPS) mode based on the direction of the electric fields applied to the LC molecules. Among those modes, the IPS-LCD provides a wider viewing angle of about 160°.

[0006] Please refer to FIG. **1**, which is a schematic drawing illustrating a conventional transflective IPS-LCD. As shown in FIG. **1**, the conventional transflective IPS-LCD **100** includes a thin film transistor (TFT) array substrate **102**, a color filter (CF) substrate **104** opposite to the TFT array substrate **102**, and a liquid crystal (LC) layer positioned between the TFT array substrate **102** and the CF substrate **104**. The LC layer includes a plurality of LC molecules **106**. The conventional transflective IPS-LCD **100** also includes a plurality of pixel regions **110** and each of the pixel regions **110** includes a transmissive region **112** and a reflective region **114**. A TFT (not shown) is positioned in each pixel region **110** defined on the TFT array substrate **102** and an insulating layer **130** covering the TFT is formed on the TFT array substrate **102**. Furthermore, the insulating layer **130** in the reflective region **114** includes a predetermined concave-convex pattern formed by a photomask. A reflective layer **140** is formed on the insulating layer **130** in the reflective region **114** and thus the reflective layer **140** obtains a rough surface profile along the concave-convex pattern of the insulating layer **130**. By forming the rough surface of the reflective layer **140**, the reflectivity is improved. A pixel electrode **150** comprising transparent conductive material is formed and electrically connected to the TFT through a contact hole (not shown) in the insulating layer **130**.

[0007] Please refer to FIG. **2**, which is a schematic diagram illustrating lines of electric force in a portion of pixel region of the conventional transflective IPS-LCD. It is noteworthy, the conventional transflective IPS-LCD **100** further includes a common electrode **152** positioned on the TFT array substrate **102**. The common electrode **152** and the pixel electrode **150** respectively include a comb-teeth (not shown) that are mutually interlaced and electrically isolated from each other by another insulating layer **132**. It is well-known to those skilled in the art that when voltages are respectively applied to the pixel electrode **150** and the common electrode **152**, electric fields parallel with the TFT array substrate **102** and the CF substrate **104** are generated, and consequently the LC molecules **106** are directed to be parallel with the TFT array substrate **102** for controlling the transmittance of lights.

[0008] It is noteworthy that due to the concave-convex pattern of the insulating layer **130**, the common electrode **152**, the reflective layer **140** and the insulating layer **132** formed on the insulating layer **130** in the reflective region **114** of the TFT array substrate **102** all obtain the rough surface profile along the concave-convex pattern. Consequently, the pixel electrode **150** on the insulating layer **132** is formed to have different tilt angles as shown in FIG. **2**. Accordingly, the electric fields in the transmissive region **112** are parallel with the TFT array substrate **102** and the CF substrate **104** as predetermined and required, and the LC molecules **106** are arranged to be parallel with the TFT array substrate **102** and the CF substrate **104**. However, the electric fields in the reflective region **114** interfere with each other due to the common electrode **152** and the pixel electrode **150** having the abovementioned tile angles. Consequently, the LC molecules **106** are not arranged parallel with the TFT array substrate **102** and the CF substrate **104** as predetermined and required. Therefore the transmittance of light in the reflective region **114** is adversely impacted. In other words, the rough surface of reflective layer **140** in the reflective region **114** improves the reflectivity but deteriorates the transmittance in the reflective region **114**. Accordingly, the brightness in the transmissive region **112** and the reflective region **114** of a single pixel region **110** is not uniform.

[0009] Therefore, it is still in need to have a transflective IPS-LCD having the rough surface for improving the reflectivity in the reflective region without adversely impacting the electrical field distribution and the transmittance in the reflective region.

SUMMARY OF THE INVENTION

[0010] Therefore, the present invention provides a transflective IPS-LCD having improved reflectivity without adversely impacting the electrical field distribution.

[0011] According to an aspect of the present invention, a transflective LCD is provided. The transflective LCD includes a color filter (CF) substrate having a transmissive region and a reflective region defined thereon, a thin film transistor (TFT) substrate having the transmissive region and the reflective region defined thereon, a liquid crystal (LC) layer sandwiched in between the CF substrate and the TFT array substrate, and at least a conductive spacer positioned in between the CF substrate and the TFT array substrate. The CF substrate further includes a color filter array, at least a pixel electrode, and at least a common electrode positioned between the color filter array and the pixel electrode. The common electrode is electrically isolated from the pixel electrode. The TFT array substrate further includes at least a TFT positioned in the transmissive region and at least a reflector positioned in the reflective region. The TFT includes a gate, a source and a drain. The conductive spacer positioned in between the CF substrate and the TFT array substrate is electrically connected to the drain and the pixel electrode.

[0012] According to the transflective IPS-LCD provided by the present invention, the reflector having the rough surface for improving reflectivity is formed on the TFT array substrate while the common electrode and the pixel electrode for generating the electric fields are formed on the CF substrate. Therefore, the common electrode and the pixel electrode are not impacted by the rough surface of the reflector. Accordingly, the electric fields generated by the common electrode

and the pixel electrode are always parallel with the CF substrate and the TFT array substrate in both of the transmissive region and the reflective region. Consequently, the transflective IPS-LCD provided by the present invention simultaneously improves the reflectivity and the transmittance, and thus a transflective IPS-LCD providing an uniform brightness is obtained.

[0013] These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is a schematic drawing illustrating a conventional transflective IPS-LCD;

[0015] FIG. **2** is a schematic diagram illustrating lines of electric force in a portion of pixel region of the conventional transflective IPS-LCD;

[0016] FIG. **3** is a schematic drawing illustrating a transflective IPS-LCD provided by a preferred embodiment of the present invention; and

[0017] FIG. **4** is a schematic diagram illustrating lines of electric force in a portion of the transflective IPS-LCD provided by the preferred embodiment.

DETAILED DESCRIPTION

[0018] Certain terms are used throughout the description and following claims to refer to particular components. As one skilled in the art will appreciate, electronic equipment manufacturers may refer to a component by different names. This document does not intend to distinguish between components that differ in name but not function. In the following description and in the claims, the terms "include" and "comprise" are used in an open-ended fashion, and thus should be interpreted to mean "include, but not limited to . . . ".

[0019] Please refer to FIG. **3** and FIG. **4**, wherein FIG. **3** is a schematic drawing illustrating a transflective IPS-LCD provided by a preferred embodiment of the present invention and FIG. **4** is a schematic diagram illustrating lines of electric force in a portion of the transflective IPS-LCD provided by the preferred embodiment. As shown in FIG. **3**, the transflective IPS-LCD **200** provided by the present invention includes a color filter (CF) substrate **202**, a TFT array substrate **204**, and a liquid crystal (LC) layer **206** sandwiched in between the CF substrate **202** and the TFT array substrate **204**. The LC layer **206** includes a plurality of LC molecules **206***a*. It is noteworthy that in the preferred embodiment, the CF substrate **202** and the TFT array substrate **204** of the transflective IPS-LCD **200** both have a plurality of pixel regions **210** respectively including a transmissive region **212** and a reflective region **214** defined thereon.

[0020] Please refer to FIG. **3** again. The CF substrate **202** includes a transparent substrate **220** and a color filter array **222** positioned on the transparent substrate **220** at the side facing the TFT array substrate **204**. Those skilled in the art would easily realize a variety of the color filter array **222** architecture usually based on different combinations of primary colors (red, green, blue), complementary colors (cyan, magenta, yellow), or white can be chosen. Since the color filter array **222** architecture and patterns are well-known to those skilled in the art, those details are omitted herein in the interest of brevity. As shown in FIG. **3**, cell gaps in the transmissive region **212** and the reflective region **214** of the transflective IPS-LCD **200** of the preferred embodiment are substantially the same, but not limited to this. The cell gap in the reflective region **214** can be a half of the cell gap of the transmissive region **212** in the preferred embodiment. Additionally, since the cell gaps in the transmissive region **212** and the reflective region **214** are the same in the preferred embodiment, phase retardations and brightness values are accordingly different in the transmissive region **212** and the reflective region **214**. As a countermeasure against to the problems, an in-cell retarder **224** is formed on the CF substrate **202** in the reflective region **214** according to the preferred embodiment. The CF substrate **202** of the preferred embodiment further includes a common electrode **226** formed on the CF substrate **202**. The common electrode **226** can include transparent metal oxide material such as Indium Tin Oxide (ITO) or Indium Zinc Oxide (IZO). In the preferred embodiment, a first insulating layer **230** is formed on the common electrode **226** and at least a pixel electrode **228** is formed on the first insulating layer **230**. The pixel electrode **228** also can include ITO or IZO. As shown in FIG. **3**, the common electrode **226** is positioned in between the color filter array **222** and the pixel electrode **228** in a direction vertical to the CF substrate **202**, and the common electrode **226** is electrically isolated from the pixel electrode **228** by the first insulating layer **230**. The common electrode **226** and the pixel electrode **228** respectively include a comb-teeth (not shown) that are mutually interlaced, but not limited to this.

[0021] Please still refer to FIG. **3**. The TFT array substrate **204** includes a transparent substrate **240** having a plurality of scan lines and data lines (not shown) arranged in crossover. And at least a TFT **242** serving as the switch device for a pixel is positioned at each of intersections of the scan lines and the data lines. As mentioned above, the TFT array substrate **204** also includes the transmissive region **212** and the reflective region **214** defined thereon. In the preferred embodiment, at least a reflector **244** is positioned in the reflective region **214** and the TFT **242** is positioned in the transmissive region **212**. However, it is not limited to form the TFT **242** in the reflective region **214** if required. As those skilled in the art know, the TFT **242** further includes a gate **242***a*, a source **242***b* and a drain **242***c*. Furthermore, a second insulating layer **232** covering the TFT **242** is formed on the TFT array substrate **204** both in the transmissive region **212** and the reflective region **214**. The second insulating layer can be an organic insulating layer, but not limited to this. And the reflector **244** is positioned on the second insulating layer **232**. For improving reflectivity in the reflective region **214**, the second insulating layer **232** is patterned to have a predetermined concave-convex pattern by a photomask having a predetermined pattern, and the reflector **244** formed on the second insulating layer **232** obtains a rough surface along the predetermined concave-convex pattern of the second insulating layer **232** in the reflective region **214**. In addition, the second insulating layer **232** includes a contact hole **234** for exposing the drain **242***c* of the TFT **242** in the transmissive region **212**.

[0022] The gate **242***a* of the TFT **242** is electrically connected to the scan line and the source **242***b* is electrically connected to the data line. It is noteworthy that a conductive spacer **208** is positioned in between the CF substrate **202** and the TFT array substrate **204** in the preferred embodiment. The conductive spacer **208** is electrically connected to the drain **242***c* positioned on the TFT array substrate **204** through the contact hole **234** in the second insulating layer **232** and to the

pixel electrode **228** positioned on the CF substrate **202**. The conductive spacer **208** includes conductive material such as Al, Ag, or AlNd, but not limited to this. Furthermore, the conductive spacer **208** can include an insulating material and a conductive layer coating on the insulating material.

[0023] Please refer to FIG. **3** and FIG. **4**. According to the transflective IPS-LCD **200** provided by the preferred embodiment, the pixel electrode **228** and the common electrode **226** are positioned on the CF substrate **202**, instead of on the TFT array substrate **204** while the TFT **242** serving as the switch device is still positioned on the TFT array substrate **204**. It is noteworthy that the drain **242***c* of the TFT **242** is electrically connected to the pixel electrode **228** by the conductive spacer **208** that is positioned in between the CF substrate **202** and the TFT array substrate **204**. Accordingly, signal transmission between the drain **242***c* and the pixel electrode **228** is not impacted at all. Furthermore, the reflectors **244** in each of the reflective regions **214** still obtain the rough surface for improving reflectivity by forming along the concave-convex pattern of the second insulating layer **232**. More important, since the pixel electrode **228** and the common electrode **226** are positioned on the CF substrate **202** having the even surface, when the voltages are respectively applied to the common electrode **226** and the pixel electrode **228**, the generated electric fields are always parallel with the CF substrate **202** and the TFT array substrate **204** without affecting each other as shown in FIG. **4**. Consequently, the LC molecules **206***a* in the LC layer **206** are arranged parallel with the CF substrate **202** and the TFT array substrate **204** both in the transmissive region **212** and the reflective region **214** as desired and required. Thus the same transmittances in both of the transmissive region **212** and the reflective region **214** are achieved.

[0024] As mentioned above, according to the transflective IPS-LCD provided by the present invention, the reflector having the rough surface for improving the reflectivity is formed on the TFT array substrate while the common electrode and the pixel electrode for generating the electric fields are formed on the CF substrate. Therefore, the common electrode and the pixel electrode are not impacted by rough surface of the reflector. Accordingly, the electric fields generated by the common electrode and the pixel electrode are always parallel with the CF substrate and the TFT array substrate in both of the transmissive region and the reflective region. Furthermore, by providing the conductive spacer in between the CF substrate and the TFT array substrate, the electrical connection and the signal transmission between the pixel electrode and the TFT are still constructed. Consequently, the transflective IPS-LCD provided by the present invention simultaneously improves the reflectivity and the transmittance, and thus a transflective IPS-LCD having an uniform brightness is obtained.

[0025] Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention.

What is claimed is:

1. A transflective liquid crystal display (LCD) comprising:
- a color filter (CF) substrate having a transmissive region and a reflective region defined thereon, the CF substrate further comprising:
  - a color filter array;
  - at least a pixel electrode; and
  - a common electrode positioned between the color filter array and the pixel electrode, the common electrode being electrically isolated from the pixel electrode;
- a thin film transistor (TFT) array substrate having the transmissive region and the reflective region defined thereon, the TFT array substrate further comprising:
  - at least a thin film transistor positioned in the transmissive region, the thin film transistor having a gate, a source and a drain; and
  - at least a reflector positioned in the reflective region;
- a liquid crystal (LC) layer sandwiched in between the CF substrate and the TFT array substrate; and
- at least a conductive spacer positioned in between the CF substrate and the TFT array substrate and electrically connected to the drain and the pixel electrode.

2. The transflective LCD of claim **1**, further comprising a first insulating layer electrically isolating the common electrode from the pixel electrode formed on the color filter array.

3. The transflective LCD of claim **1**, further comprising a second insulating layer formed on the TFT array substrate in the transmissive region and the reflective region.

4. The transflective LCD of claim **3**, wherein the second insulating layer in the reflective region comprises a rough surface.

5. The transflective LCD of claim **4**, wherein the reflector is positioned on the rough surface of the second insulating layer.

6. The transflective LCD of claim **3**, wherein the second insulating layer further comprises a contact hole exposing the drain in the transmissive region, and the conductive spacer is electrically connected to the drain and the pixel electrode through the contact hole.

7. The transflective LCD of claim **1**, further comprising an in-cell retarder positioned in the reflective region in the CF substrate.

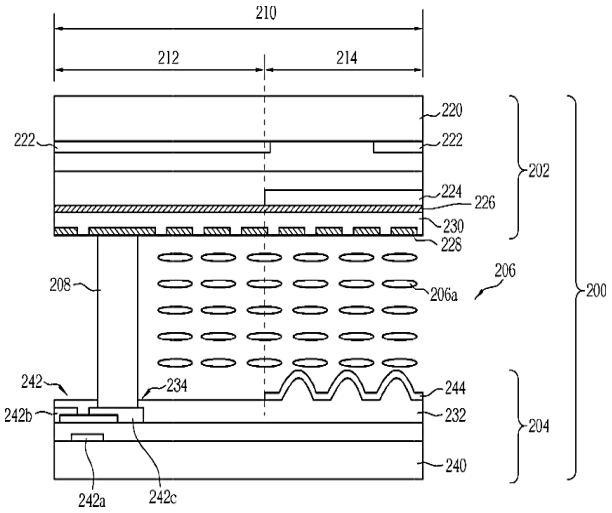
8. The transflective LCD of claim **1**, wherein the conductive spacer comprises a conductive material.

9. The transflective LCD of claim **8**, wherein the conductive material comprises Al, Ag or AlNd.

10. The transflective LCD of claim **1**, wherein the conductive spacer comprises an insulating material and a conductive layer coating on the insulating material.

* * * * *

专利名称(译)	透反液晶显示面板		
公开(公告)号	US20120062812A1	公开(公告)日	2012-03-15
申请号	US12/911726	申请日	2010-10-26
[标]申请(专利权)人(译)	吴博融		
申请(专利权)人(译)	吴伯荣		
当前申请(专利权)人(译)	中华映管股份有限公司.		
[标]发明人	WU BO RONG		
发明人	WU, BO-RONG		
IPC分类号	G02F1/1335 G02F1/1368 G02F1/1339		
CPC分类号	G02F1/133555 G02F1/1368 G02F1/134363 G02F1/13394		
优先权	099217486 2010-09-09 TW		
外部链接	Espacenet USPTO		

摘要(译)

透反液晶显示面板包括滤色器基板和薄膜晶体管阵列基板，薄膜晶体管阵列基板具有透射区域和限定在其上的反射区域，位于CF基板和TFT阵列基板之间的液晶层，以及至少一个导电隔板位于CF基板和TFT阵列基板之间。CF基板包括滤色器阵列，至少像素电极和位于像素电极和CF阵列之间的公共电极。公共电极与像素电极电隔离。TFT阵列基板至少包括具有栅极的TFT，位于透射区域中的源极和漏极，以及至少位于反射区域中的反射器。导电间隔物将位于CF基板上的像素电极电连接到位于TFT阵列基板上的漏极。