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(54) IN PLANE SWITCHING LIQUID CRYSTAL DISPLAY WITH TRANSFLECTOR

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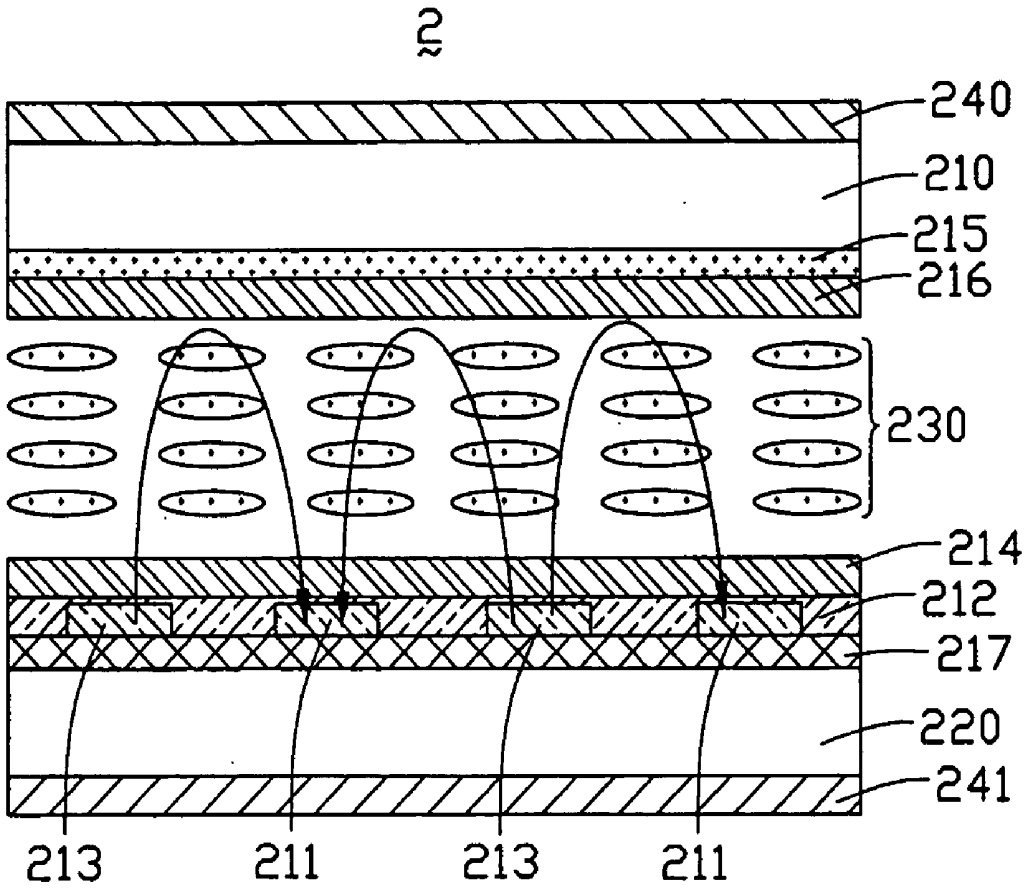
(57) **ABSTRACT**

An in plane switching liquid crystal display (**2**) includes a first substrate (**220**) and a second substrate (**210**) disposed opposite each other and spaced apart a predetermined distance. A liquid crystal layer is interposed between the first substrate and the second substrate, the liquid crystal layer containing a plurality of liquid crystal molecules (**230**). A plurality of pixel electrodes (**213**) and a plurality of counter electrodes (**211**) are formed on the first substrate in parallel alternating fashion. Two polarizers (**240, 241**) are disposed on the first substrate and the second substrate, respectively. A transflector (**217**) capable of transmitting and reflecting light beams is disposed on the first substrate. The in plane switching liquid crystal display can thus utilize ambient light beams as well as light beams provided by a backlight, so that the in plane switching liquid crystal display has low power consumption.



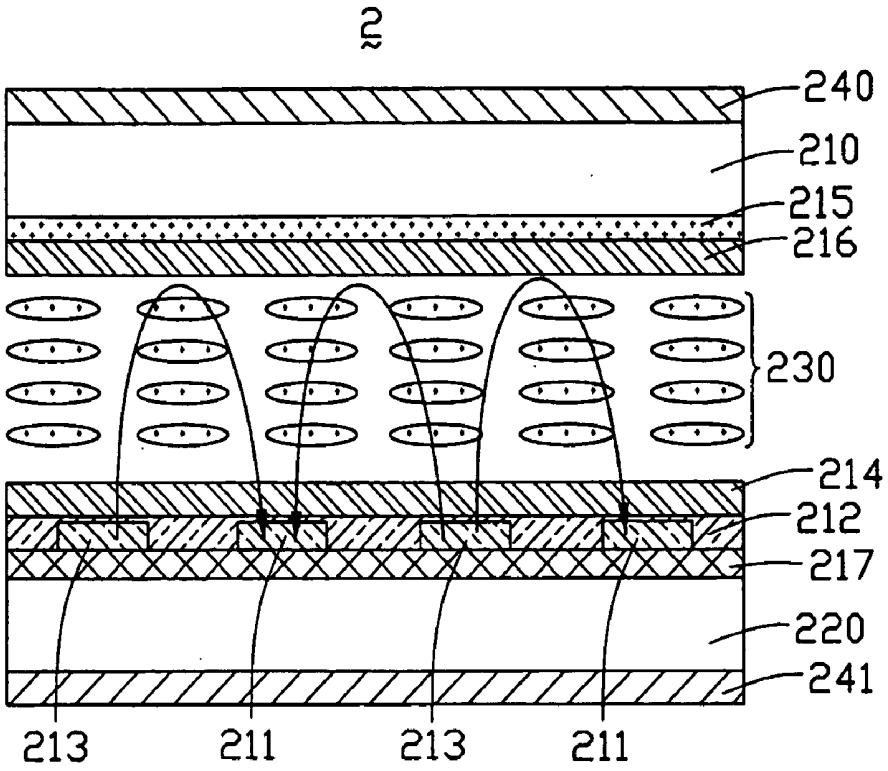

2
240
210
215
216
230
214
212
217
220
241
213
211
213
211

FIG. 1

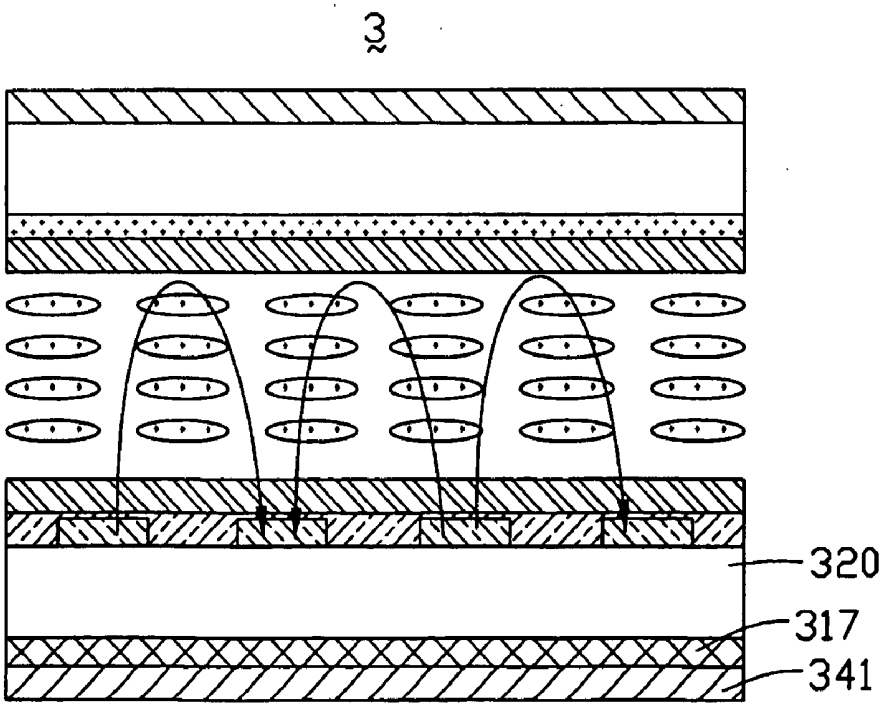

3
320
317
341

FIG. 2

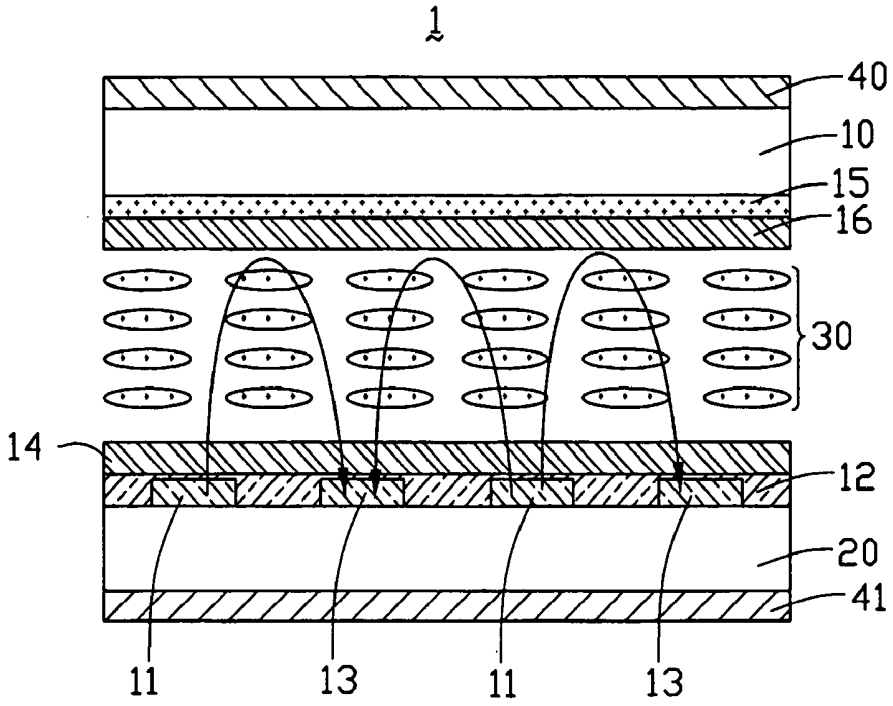


FIG. 3
(PRIOR ART)

IN PLANE SWITCHING LIQUID CRYSTAL DISPLAY WITH TRANSFLECTOR

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to in plane switching liquid crystal displays (IPS-LCDs), and especially to a transflective mode IPS-LCD having low power consumption.

[0003] 2. Description of the Prior Art

[0004] The in-plane switching liquid crystal display (IPS-LCD) has been developed in order to improve on the narrow viewing angle of the more traditional twisted nematic liquid crystal display (TN-LCD). The IPS-LCD has a plurality of counter electrodes and a plurality of pixel electrodes all disposed on a same substrate of two opposite substrates, for driving liquid crystal molecules that are disposed in a liquid crystal layer between the substrates. The resulting electric field is substantially planar and parallel to a surface of said same substrate. This configuration provides an improved viewing angle for the IPS-LCD.

[0005] Referring to **FIG. 3**, this is a cross-sectional representation of a conventional IPS-LCD **1**. The IPS-LCD **1** is a transmissive mode LCD, which utilizes a backlight for illuminating. The IPS-LCD **1** comprises an upper substrate **10** and a lower substrate **20** disposed opposite to each other and spaced apart a predetermined distance. A liquid crystal layer (not labeled) having a plurality of liquid crystal molecules **30** is disposed between the upper and lower substrates **10**, **20**. A plurality of counter electrodes **11** and a plurality of pixel electrodes **13** are disposed on the lower substrate **20**, with an insulating layer **12** and an alignment film **14** disposed on the counter and pixel electrodes **11**, **13**, in that order from bottom to top. A lower polarizer **41** is formed on an undersurface of the lower substrate **20**, the lower polarizer **41** being an ordinary type polarizer. A color filter **15** and an alignment film **16** are disposed on an undersurface of the upper substrate **10**, in that order from top to bottom.

[0006] An upper polarizer **40** is formed on a top surface of the upper substrate **10**, the upper polarizer **40** also being an ordinary type polarizer. Polarization axes of the upper polarizer **40** and the lower polarizer **41** are perpendicular to each other.

[0007] The color filter **15** comprises a black matrix (not shown), and a color resin layer (not shown) having Red, Green and Blue segments. The color filter **15** is disposed between (but not adjacent) the upper polarizer **40** and the liquid crystal layer. The color filter **15** has a de-polarizing effect on light beams passing therethrough due to pigment light scattering, therefore light beams passing through the IPS-LCD **1** are at least partially de-polarized by the color filter **15** before reaching the upper polarizer **40**. This de-polarizing of the light beams prior to them reaching the upper polarizer **40** can reduce the contrast ratio of the IPS-LCD **1**. Even though such de-polarizing effects are small, they can have a significant effect on the contrast ratio of the IPS-LCD **1**.

[0008] The counter electrodes **11** and the pixel electrodes **13** are strip-shaped, and are arranged parallel to each other in alternating fashion. The counter electrodes **11** and the pixel electrodes **13** are transparent conductors, being made of a material such as indium tin oxide (ITO). When the IPS-LCD **1** is driven, an electric field having a component parallel to main surfaces of the substrates **10**, **20** is formed at upper portions of the counter electrodes **11** and the pixel electrodes **13**. The liquid crystal molecules **30** disposed over the counter and pixel electrodes **11**, **13** are driven, thus giving the IPS-LCD **1** an improved wide viewing angle compared to that of a TN-LCD.

[0009] However, the IPS-LCD **1** is a transmissive mode LCD, which depends on a backlight for illumination. The backlight typically uses 50% or more of the total power consumed by the IPS-LCD **1**.

[0010] It is desired to provide an IPS-LCD that can solve the above-mentioned high power consumption problem.

SUMMARY OF THE INVENTION

[0011] An object of the present invention is to provide an in plane switching liquid crystal display which has low power consumption.

[0012] To achieve the above object, an in plane switching liquid crystal display of the present invention includes a first substrate and a second substrate disposed opposite each other and spaced apart a predetermined distance. A liquid crystal layer is interposed between the first substrate and the second substrate, with a plurality of liquid crystal molecules contained in the liquid crystal layer. A plurality of pixel electrodes and a plurality of counter electrodes are formed on the first substrate in alternating fashion. Two polarizers are disposed on the first substrate and the second substrate, respectively. A transflector capable of transmitting and reflecting light beams is disposed on the first substrate. The in plane switching liquid crystal display can thus utilize ambient light beams as well as light beams provided by a backlight, so that the in plane switching liquid crystal display has low power consumption.

[0013] Other objects, advantages, and novel features of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] **FIG. 1** is a schematic, cross-sectional view of part of an IPS-LCD according to a first embodiment of the present invention;

[0015] **FIG. 2** is a schematic, cross-sectional view of part of an IPS-LCD according to a second embodiment of the present invention; and

[0016] **FIG. 3** is a schematic, cross-sectional view of part of a conventional IPS-LCD.

DETAILED DESCRIPTION OF THE INVENTION

[0017] **FIG. 1** is a schematic, cross-sectional view of an in plane switching liquid crystal display (IPS-LCD) **2** according to the first embodiment of the present invention. The IPS-LCD **2** comprises a first substrate **220**, a second substrate **210**, and a liquid crystal layer (not labeled) having a plurality of liquid crystal molecules **230**. The first substrate

220 and the second substrate **210** are spaced apart from each other, and the liquid crystal layer is disposed therebetween. The first substrate **220** and the second substrate **210** are made of glass. Alternatively, the first substrate **220** and the second substrate **210** can be made of silicon dioxide (SiO_2).

[**0018**] A plurality of gate bus lines (not shown) and a plurality of data bus lines (not shown) are cross-arranged on an inner surface of the first substrate **220**. A plurality of thin film transistors (not shown) is disposed at intersections of the gate bus lines and the data bus lines. A plurality of counter electrodes **211** and a plurality of pixel electrodes **213** are disposed on the first substrate **220**, with a transparent insulating layer **212** and an alignment film **214** disposed on the counter and pixel electrodes **211**, **213** in that order from bottom to top. A transflector **217** is interposed between the counter and pixel electrodes **211**, **213** and the first substrate **220**. A color filer **215** and an alignment film **216** are formed on an underside of the second substrate **210**, in that order from top to bottom. Two polarizers **241**, **240** are formed on two outer surfaces of the first substrate **220** and the second substrate **210**, respectively.

[**0019**] The alignment films **214**, **216** are horizontal alignment layers. Alignment directions of the alignment films **214**, **216** are parallel to each other, or alternatively an angle of **180** degrees may be formed between the alignment directions. Polarization axes of the polarizers **241**, **240** are perpendicular to each other. The polarizers **241**, **240** are ordinary type polarizers. The alignment direction of the alignment film **214** is parallel to the polarization axis of the polarizer **241**.

[**0020**] The counter electrodes **213** and the pixel electrodes **211** are strip-shaped, and are arranged parallel to each other in alternating fashion on the transflector **217**. The counter electrodes **213** and the pixel electrodes **211** are made of a transparent conductor, such as indium tin oxide (ITO) or indium zinc oxide (IZO). The transparent insulating layer **212** is made of SiO_2 or silicon nitride (SiNx), to prevent the counter electrodes **213** and the pixel electrodes **211** from shorting and to protect them.

[**0021**] The transflector **217** is a multiple-layered structure, with ITO layers (not shown) and titanium dioxide (TiO_2) layers (not shown) stacked one on the other in alternating fashion. Each ITO layer has a high refractive index, and each TiO_2 layer has a low refractive index. Therefore, the multiple-layer structure can reflect light beams as well as transmit light beams. A desired ratio of light beams reflected by the transflector **217** to light beams transmitted by the transflector **217** is obtained by selecting the thicknesses and the refractive indexes of the layers having different refractive indexes accordingly.

[**0022**] The color filter **215** comprises a black matrix (not shown), and a color resin layer (not shown) having Red, Green and Blue segments. The black matrix is disposed between the segments of the color resin layer. The black matrix is used to prevent light beams from leaking from the IPS-LCD **2**, and to protect the thin film transistors from damage.

[**0023**] When no voltage is applied to the counter electrodes **213** and pixel electrodes **211**, the liquid crystal molecules **230** are arranged substantially parallel to the first substrate **220** and the second substrate **210**. The state of polarization of light beams is not changed when they pass through the liquid crystal layer. Therefore the light beams, whether they be light beams from a backlight or light beams from the ambient environment, cannot pass through the polarizer **240**. As a result, the IPS-LCD **2** is in a dark state. When a voltage is applied to the counter electrodes **213** and the pixel electrodes **211**, an electric field having horizontal components is produced therebetween. Long axes of the liquid crystal molecules **230** are parallel to the direction of the horizontal components of the electric field. The polarization state of light beams is changed when the light beams pass through the liquid crystal layer. Therefore the light beams can pass through the polarizer **240**. As a result, the IPS-LCD **2** is in a white state.

[**0024**] The transflector **217** can reflect ambient light beams and transmit light beams from a backlight for display. Therefore, the IPS-LCD **2** is a transflective mode liquid crystal display. Because the transflective mode LCD can make use of both internal and external light sources, it can be operated in a bright ambient light environment with low power consumption. Further, the IPS-LCD **2** has a wide viewing angle compared to other kinds of LCDs.

[**0025**] Referring to **FIG. 2**, this shows a schematic, cross-sectional view of an IPS-LCD **3** according to the second embodiment of the present invention. The IPS-LCD **3** is the same as the IPS-LCD **2** of the first embodiment, except that the IPS-LCD **3** has a transflector **317** disposed between a first substrate **320** and a polarizer **341**.

[**0026**] In alternative embodiments, the transflector **217**, **317** of the present invention may be made of a material having high reflectivity, such as aluminum or silver. Further, the transflector **217**, **317** may define a plurality of holes therein for free transmission of light beams therethrough. The holes may, for example, be circular, elliptical or polygonal. A desired ratio of light beams reflected by the transflector **217**, **317** to light beams transmitted by the transflector **217**, **317** is obtained by configuring areas of the holes accordingly.

[**0027**] In other alternative embodiments, at least one of the polarizers **240**, **241**, **341** of the present invention may be an extraordinary type polarizer. The extraordinary type polarizer can improve a transmission ratio and an aperture ratio of the IPS-LCD **2**, **3**. Further, the polarizer **240** can be disposed between the color filter **215** and the alignment film **216**. This arrangement reduces or eliminates the adverse effects of color filter de-polarizing, and yields a higher contrast ratio.

[**0028**] In still another alternative embodiment, the counter electrodes **211** and the pixel electrodes **213** are disposed on the second substrate **210** and the first substrate **220** respectively, in order to generate an electric field having horizontal components parallel to the surfaces of the first substrate **220** and the second substrate **210**.

[**0029**] In summary, the IPS-LCD **2**, **3** of the present invention is a transflective mode liquid crystal display, which can make use of both internal and external light sources. Therefore, the IPS-LCD **2**, **3** can be operated in a bright ambient light environment with low power consumption. Furthermore, the IPS-LCD **2**, **3** has a wide viewing angle compared to other kinds of LCDs.

[**0030**] It is to be understood, however, that even though numerous characteristics and advantages of the present

invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. An in plane switching liquid crystal display comprising:

a first substrate and a second substrate disposed opposite each other and spaced apart a predetermined distance;

a liquid crystal layer interposed between the first substrate and the second substrate;

a plurality of pixel electrodes and a plurality of counter electrodes formed on the first substrate;

two polarizers formed at the first substrate and the second substrate, respectively; and

a transflector disposed on the first substrate.

2. The in plane switching liquid crystal display as claimed in claim 1, wherein the transflector has a multiple-layered structure, in which layers having different refractive indexes are stacked one on the other in alternating fashion.

3. The in plane switching liquid crystal display as claimed in claim 2, wherein the transflector comprises indium tin oxide (ITO) layers and titanium dioxide (TiO_2) layers.

4. The in plane switching liquid crystal display as claimed in claim 1, wherein the transflector comprises aluminum or silver.

5. The in plane switching liquid crystal display as claimed in claim 4, wherein the transflector defines a plurality of holes.

6. The in plane switching liquid crystal display as claimed in claim 5, wherein the holes are circular, elliptical or polygonal.

7. The in plane switching liquid crystal display as claimed in claim 1, wherein the transflector is disposed between the first substrate and the liquid crystal layer, or is disposed on an undersurface of the first substrate.

8. The in plane switching liquid crystal display as claimed in claim 1, wherein each counter electrode and each pixel electrode is strip-shaped.

9. The in plane switching liquid crystal display as claimed in claim 1, wherein the polarizer of the second substrate is disposed at an inner side thereof, said inner side corresponding to the liquid crystal layer.

10. The in plane switching liquid crystal display as claimed in claim 1, wherein at least one of the polarizers is an extraordinary type polarizer.

11. An in plane switching liquid crystal display comprising:

a first substrate and a second substrate disposed opposite each other and spaced apart a predetermined distance;

a liquid crystal layer interposed between the first substrate and the second substrate;

a plurality of pixel electrodes and a plurality of counter electrodes formed on the first substrate;

two polarizers formed on the first substrate and the second substrate, respectively; and

a film disposed on the first substrate, the film being able to reflect light beams as well as transmit light beams.

12. The in plane switching liquid crystal display as claimed in claim 11, wherein the film has a multiple-layered structure, in which layers having different refractive indexes are stacked one on the other in alternating fashion.

13. The in plane switching liquid crystal display as claimed in claim 12, wherein the film comprises indium tin oxide (ITO) layers and titanium dioxide (TiO_2) layers.

14. The in plane switching liquid crystal display as claimed in claim 11, wherein the film comprises aluminum or silver.

15. The in plane switching liquid crystal display as claimed in claim 14, wherein the film defines a plurality of holes.

16. The in plane switching liquid crystal display as claimed in claim 15, wherein the holes are circular, elliptical or polygonal.

17. The in plane switching liquid crystal display as claimed in claim 11, wherein the film is disposed between the first substrate and the liquid crystal layer, or is disposed on an undersurface of the first substrate.

18. An in plane switching liquid crystal display comprising:

a first substrate and a second substrate disposed opposite each other and spaced apart a predetermined distance;

a liquid crystal layer interposed between the first substrate and the second substrate;

a plurality of pixel electrodes and a plurality of counter electrodes, wherein an electric field having horizontal components is generated between the pixel electrodes and the counter electrodes when a voltage is applied therebetween;

two polarizers formed on the first substrate and the second substrate, respectively; and

a film disposed on the first substrate, the film reflecting light beams as well as transmitting light beams.

19. The in plane switching liquid crystal display as claimed in claim 18, wherein the pixel electrodes and the counter electrodes are all disposed on the first substrate, or are disposed on the first substrate and the second substrate respectively.

* * * * *

专利名称(译)	在具有半透射反射器的平面切换液晶显示器中		
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申请号	US10/997523	申请日	2004-11-24
[标]申请(专利权)人(译)	杨秋兴留置权 陈觉JU 庞贾庞		
申请(专利权)人(译)	杨秋兴留置权 陈觉-JU 庞贾鹏		
当前申请(专利权)人(译)	群创光电		
[标]发明人	YANG CHIU LIEN CHEN CHUEH JU PANG JIA PANG		
发明人	YANG, CHIU-LIEN CHEN, CHUEH-JU PANG, JIA-PANG		
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CPC分类号	G02F1/134363 G02F1/133555		
优先权	092137543 2003-12-31 TW		
外部链接	Espacenet USPTO		

摘要(译)

面内切换液晶显示器（2）包括第一基板（220）和第二基板（210），第一基板（220）和第二基板（210）彼此相对设置并且间隔开预定距离。液晶层插入在第一基板和第二基板之间，液晶层包含多个液晶分子（230）。多个像素电极（213）和多个对电极（211）以平行交替的方式形成在第一基板上。两个偏振器（240,241）分别设置在第一基板和第二基板上。能够透射和反射光束的透射反射器（217）设置在第一基板上。因此，面内切换液晶显示器可以利用环境光束以及由背光提供的光束，使得面内切换液晶显示器具有低功耗。