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(54) OPTICAL FILM AND LIQUID CRYSTAL DISPLAY

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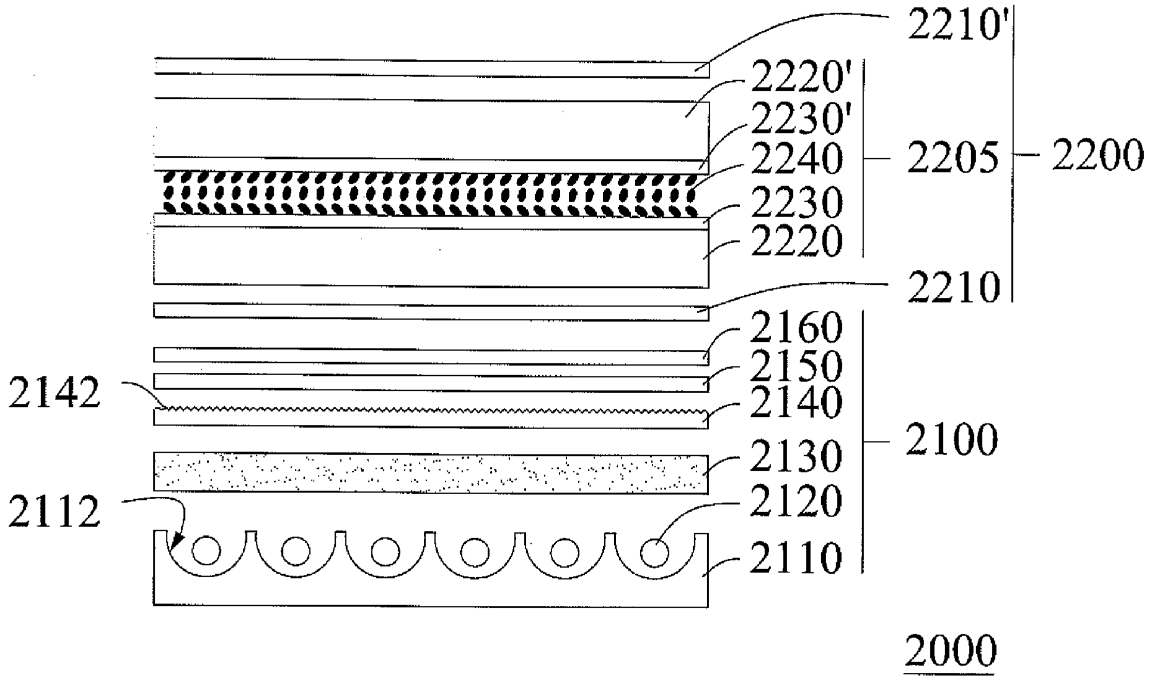
(57) **ABSTRACT**

An optical film and a liquid crystal display are provided. The liquid crystal display includes a twisted nematic type liquid crystal panel and a backlight module. The liquid crystal panel includes a bottom polarizer, a liquid crystal cell, and a top polarizer. The liquid crystal cell is placed between the bottom polarizer and the top polarizer. The backlight includes a reflective polarizer and a half-wave plate, and the half-wave plate is placed on the reflective polarizer. The transmission axis of the bottom polarizer and the principle axis of the bottom polarizer differ a first angle. The transmission axis of the bottom polarizer and the reflective polarizer differ a second angle. The first angle is half of the second angle.



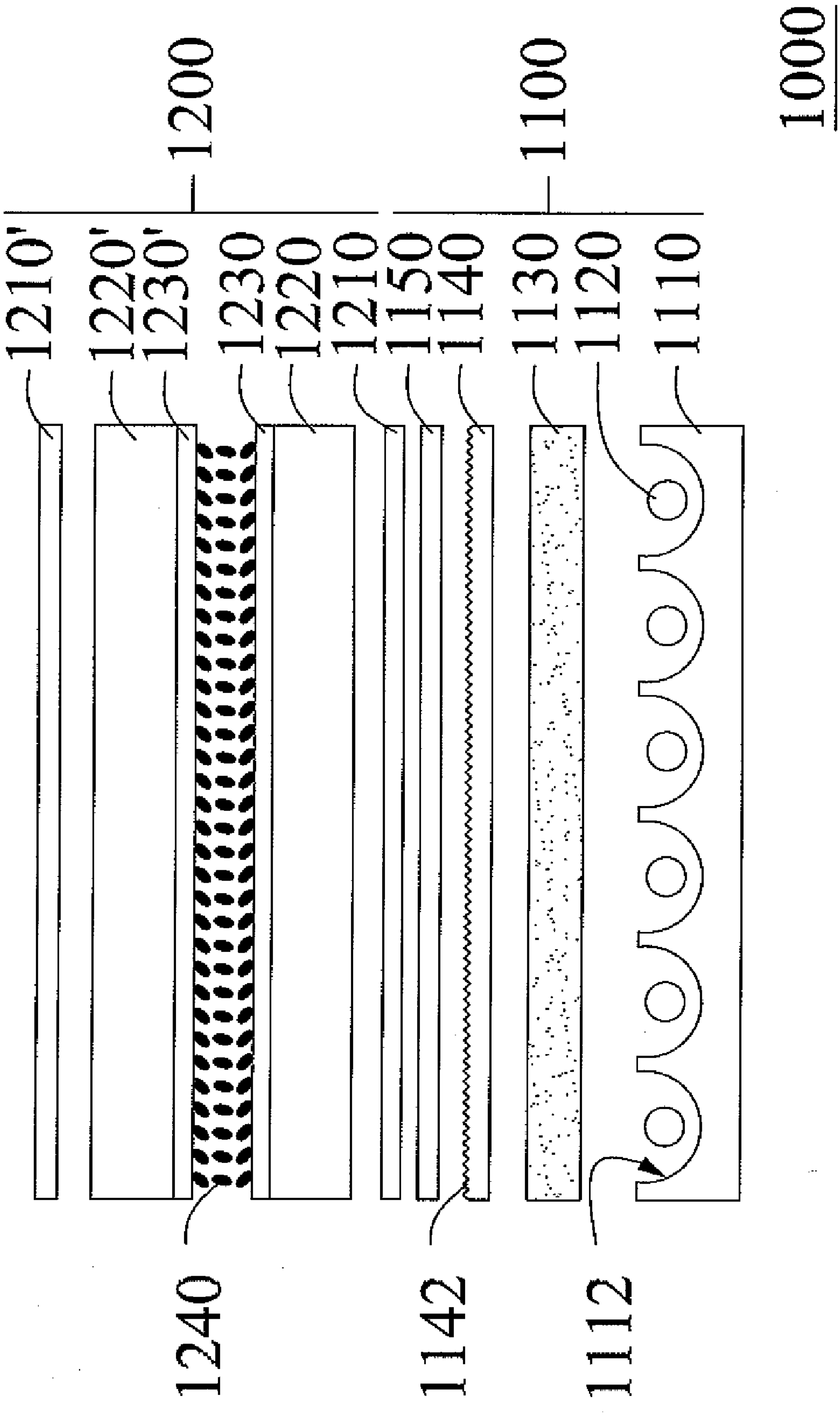

1000
1200
1100
1210'
1220'
1230'
1230
1220
1210
1150
1140
1130
1120
1110
1240
1142
1112

Fig. 1

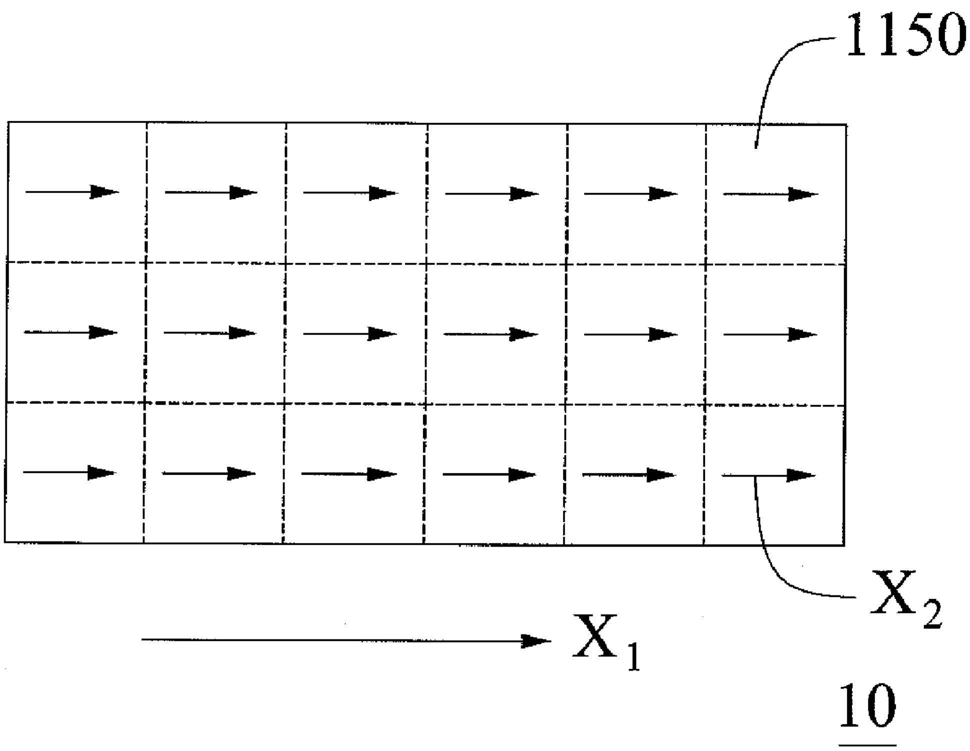


Fig. 2A

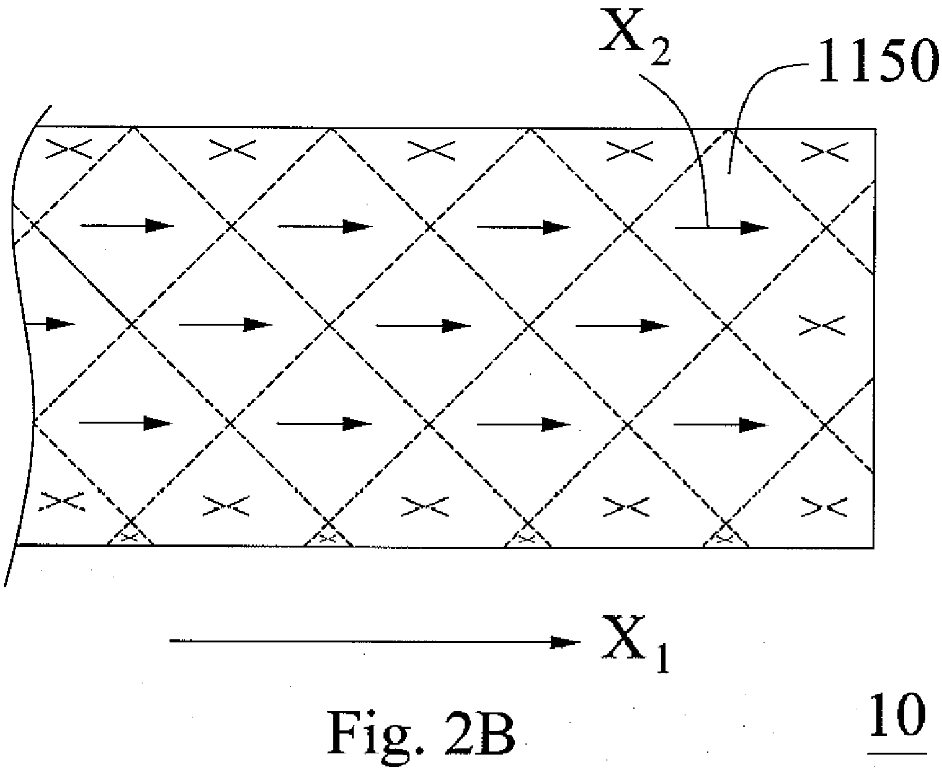


Fig. 2B

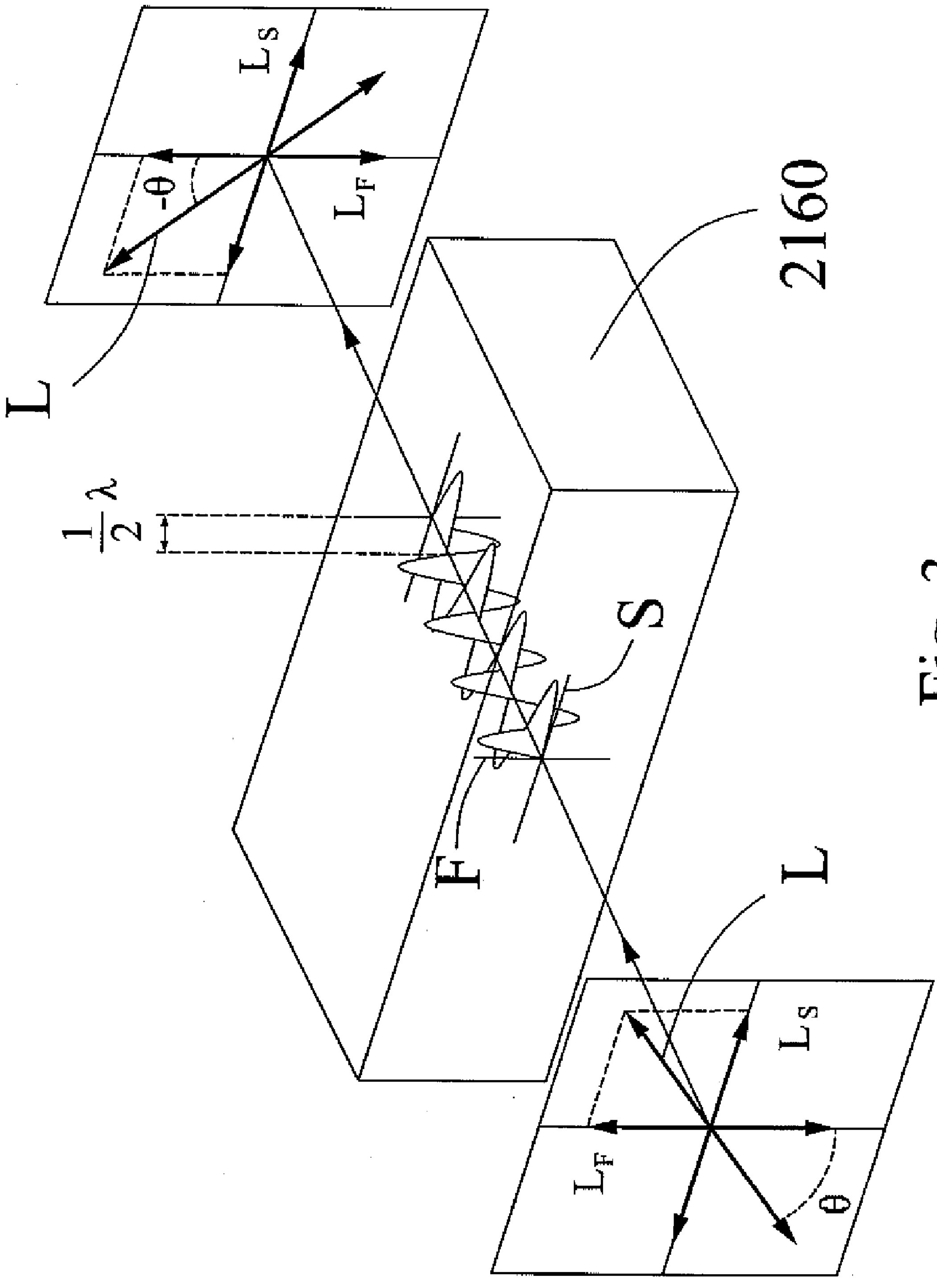


Fig. 3

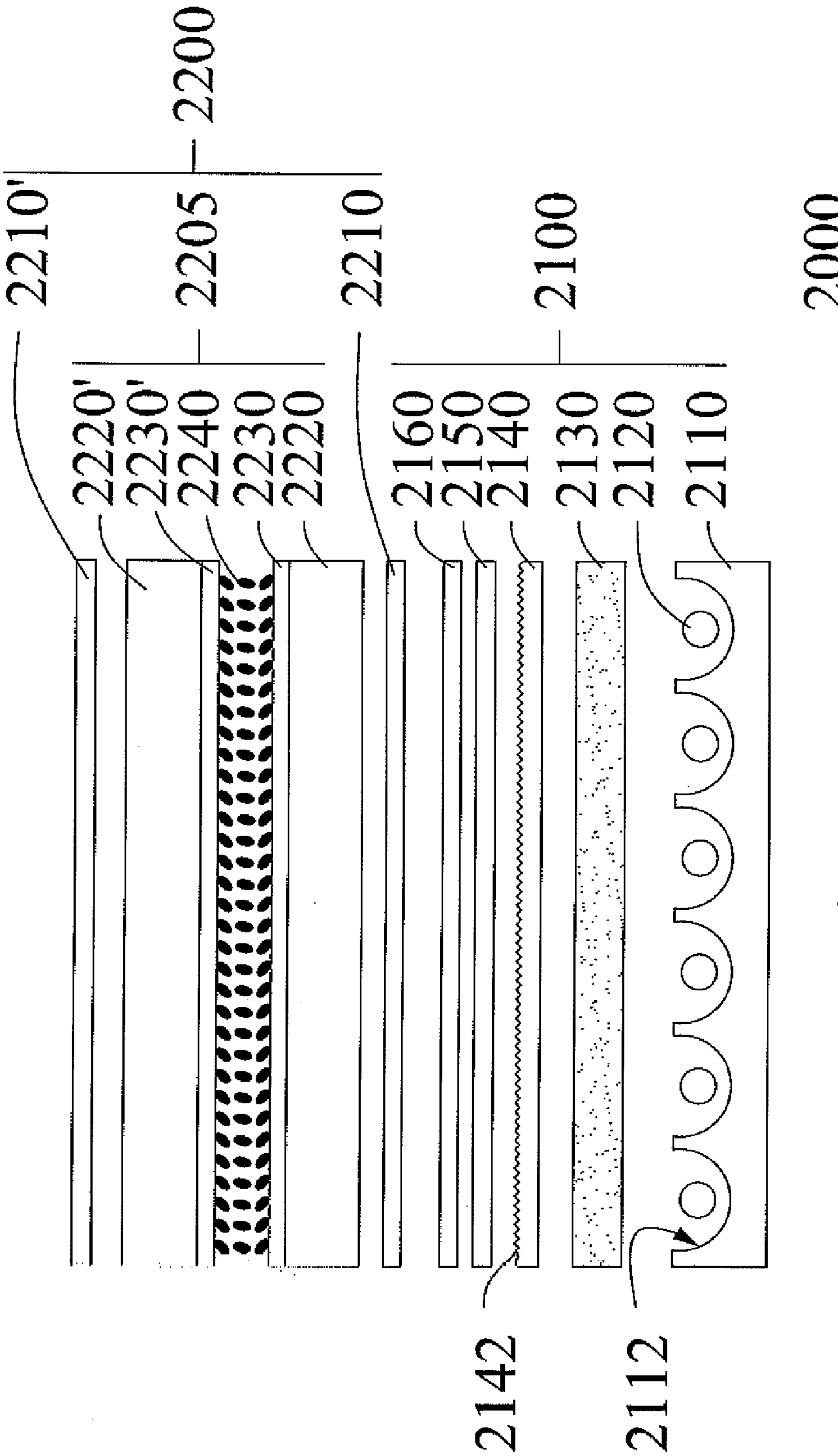

2200
2210'
2205
2210
2100
2000
2220'
2230'
2240
2230
2220
2160
2150
2140
2130
2120
2110
2142
2112

Fig. 4

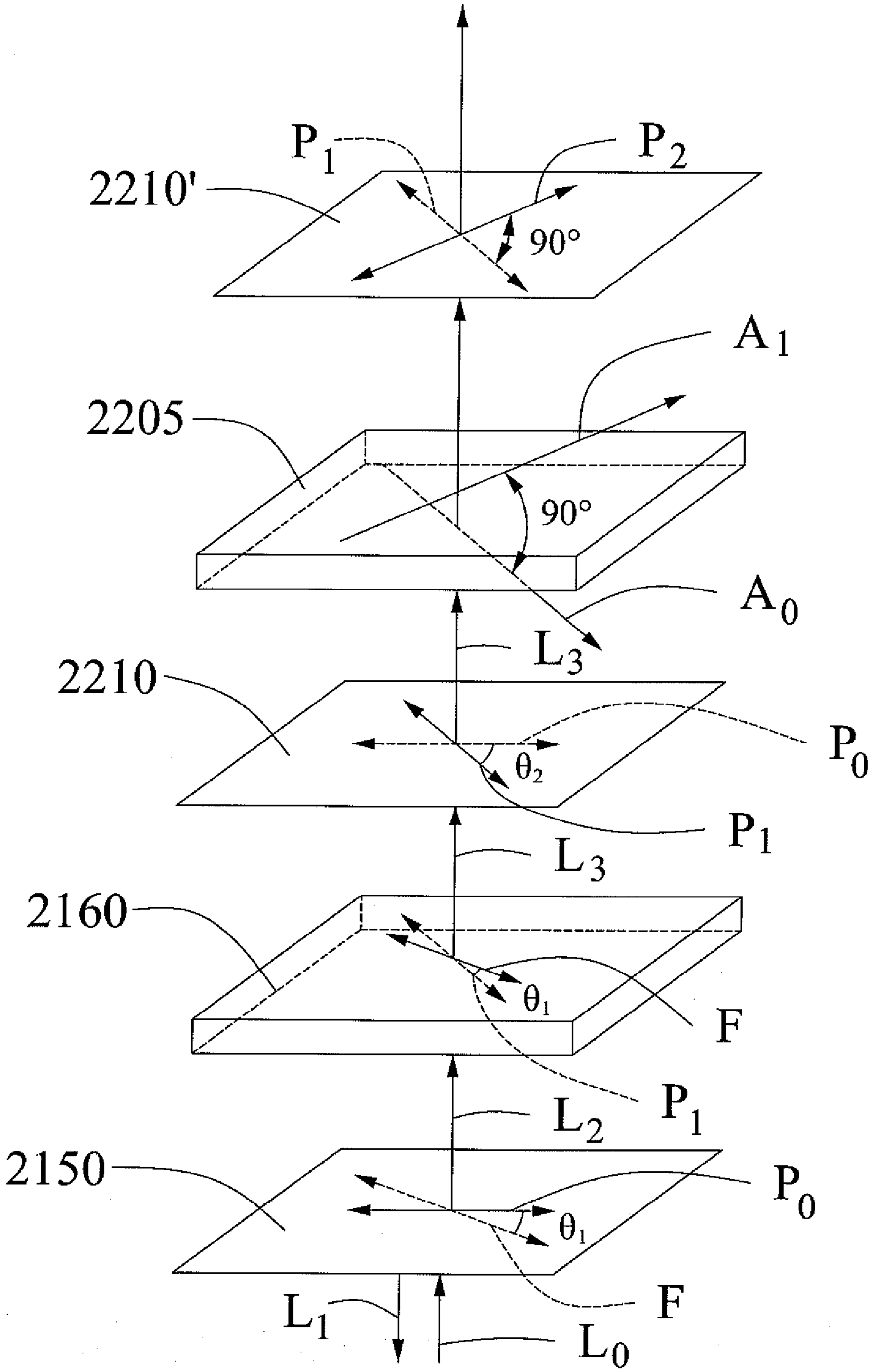

P1
P2
2210'
90°
A1
2205
90°
A0
L3
2210
P0
θ2
P1
L3
2160
θ1
F
P1
L2
2150
P0
θ1
F
L1
L0

Fig. 5

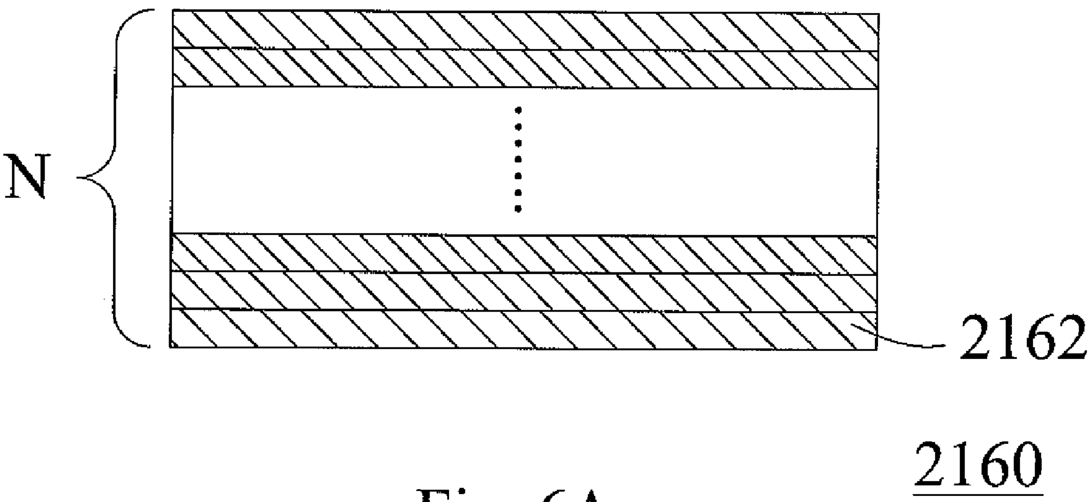


Fig. 6A

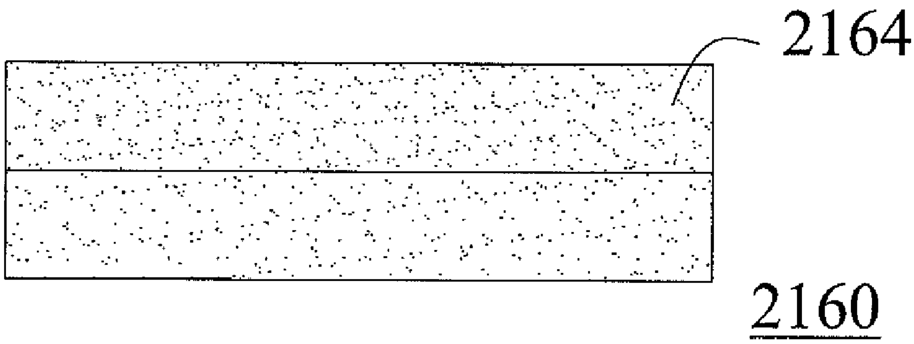


Fig. 6B

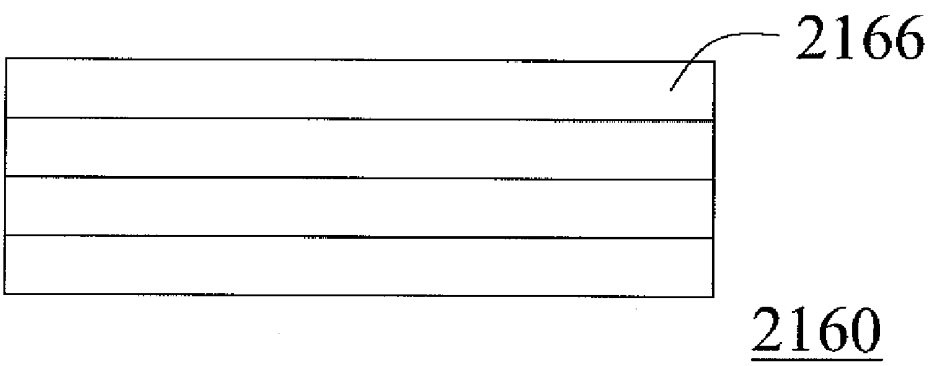


Fig. 6C

OPTICAL FILM AND LIQUID CRYSTAL DISPLAY

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a liquid crystal display and particularly to a liquid crystal display equipped with a half-wave plate.

[0003] 2. Description of the Prior Art

[0004] In recent years the traditional cathode ray tube display (commonly called CRT display) is being gradually replaced by liquid crystal display (LCD). This is mainly because the LCD releases far less radiation than the CRT display, and the production cost of LCD also drops significantly in recent years. In general, LCD consists of two main elements, namely a backlight module and a liquid crystal panel. The backlight module mainly aims to provide light to the LCD.

[0005] Refer to FIG. **1** for a conventional LCD. The LCD **1000** includes a backlight module **1100** and a liquid crystal panel **1200**. The backlight module **100** includes a casing **1110**, a plurality of lamps **1120**, a diffusion plate **1130**, a brightness-enhancement film (BEF for short) **1140** and a reflective polarizer **1150**. The lamps **1120** are located in troughs **1112** formed on the casing **1110** with the surface coated with a reflective material. The diffusion plate **1130** contains a plurality of diffusion particles. The BEF **1140** has a plurality of prism-shaped structures **1142** located at an upper side thereof. The liquid crystal panel **1200** includes a bottom polarizer **1210**, a top polarizer **1210'**, a bottom glass substrate **1220**, a top glass substrate **1220'**, a top alignment film **1230**, a bottom alignment film **1230'** and a liquid crystal layer **1240**.

[0006] As the troughs **1112** are coated with the reflective material on the surface, light emitted from the lamps **1120** can be converged to project to the diffusion plate **1130**, and the diffusion particles in the diffusion plate **1130** fully mix the incident light to make luminosity more uniform. Moreover, the prism-shaped structures **1142** on the BEF **1140** can converge light. The reflective polarizer **1150** is located above the BEF **1140**. Polarized light in a direction same as the transmission axis of the reflective polarizer **1150** can pass through the reflective polarizer **1150**, while the polarized light in a direction perpendicular to the transmission axis of the reflective polarizer **1150** is reflected by the reflective polarizer **1150**.

[0007] For the twisted nematic type (commonly called TN) liquid crystal panel **1200**, the direction of the transmission axis of the bottom polarizer **1210** must be same as that of the reflective polarizer **1150** to allow the polarized light that passes through the reflective polarizer **1150** also to pass through the bottom polarizer **1210**. The liquid crystal layer **1240** is formed by stacking multiple layers of liquid molecules. The layout direction of the liquid crystal molecules at the top layer and the bottom layer form an angle with one side of the bottom alignment film **1230'**.

[0008] In addition, when the type of the liquid crystal panel differs, the direction of the transmission axes of the bottom polarizer **1210** and the reflective polarizer **1150** generally also are different. For instance, on the TN type liquid crystal panel **1200** the direction of the transmission axes of the bottom polarizer **1210** and the reflective polarizer **1150** and two sides of the bottom polarizer **1210** form an included angle of 45□ (under the condition of the bottom polarizer **1210** formed in a square). However, for a vertial alignment (VA for short) the liquid crystal panel, the direction of the transmission axes of the bottom polarizer and the reflective polarizer are parallel with two sides of the bottom polarizer.

[0009] At present fabrication of the reflective polarizer **1150** is done by first fabricating a raw film, then cutting the raw film to produce individual sheets of the reflective polarizer **1150**. Refer to FIG. **2**A for an approach to form the reflective polarizer by cutting the raw film. The raw film **10** has a transmission axis in the direction X_1. On the reflective polarizer **1150** of the VA type liquid crystal panel, the direction X_2 of the transmission axis is parallel with one side of the reflective polarizer **1150**. Hence cutting along the broken liens shown in FIG. **2**A can get the desired reflective polarizer **1150**.

[0010] Refer to FIG. **21** for another approach to form the reflective polarizer by cutting the raw film. On the TN type liquid crystal panel the direction of the transmission axis X_2 and one side of the reflective polarizer **1150** form an angle 45□, the cutting direction also has to form 45□ with one side of the raw film **10**. As a result, scraps are produced (shown by X in FIG. **2**). Hence how to reduce the scraps during cutting the reflective polarizer is an issue remained to be overcome.

SUMMARY OF THE INVENTION

[0011] It is an object of the present invention to provide a liquid crystal display (LCD) including a reflective polarizer which is fabricated with reduced scraps.

[0012] To achieve the foregoing object the LCD of the invention includes a TN type liquid crystal panel and a backlight module. The TN type liquid crystal panel includes a bottom polarizer, a liquid crystal cell and a top polarizer. The liquid crystal cell is located between the bottom polarizer and the top polarizer. The backlight module includes a reflective polarizer and a half-wave plate located on the reflective polarizer. The half-wave plate has a principle axis (may further be differentiated to a fast axis and a slow axis) which differs from the transmission axis of the bottom polarizer for a first angle. The reflective polarizer also has a transmission axis which differs from the transmission axis of the bottom polarizer for a second angle. The first angle is one half of the second angle. In one aspect, the second angle in the TN type LCD is $\pi/4$.

[0013] In another aspect: the half-wave plate in the TN type LCD consists of N sets of ½N wave plates stacking together, where N=2 or 4.

[0014] In yet another aspect, in the TN type LCD the transmission axis of the top polarizer crosses with the transmission axis of the bottom polarizer in an orthogonal manner.

[0015] Based on the object set forth above, the invention further provides an optical film located in a liquid crystal panel which has a bottom polarizer. The optical film includes a reflective polarizer and a half-wave plate located on the reflective polarizer. The half-wave plate has a principle axis which differs from the transmission axis of the bottom polarizer for a first angle. The reflective polarizer also has a transmission axis which differs from the transmission axis of the bottom polarizer for a second angle. The first angle is one half of the second angle.

[0016] After light passes through the half-wave plate, it forms a polarized direction same as the direction of the transmission axis of the bottom polarizer. Hence the transmission axes of the reflective polarizer and the bottom polarizer of the invention do not have to be maintained in the same direction. Thus during fabrication of the reflective polarizer for the TN liquid crystal cutting can adopt the approach shown in FIG. 2A without producing scraps. Hence the cost can be reduced.

[0017] The foregoing, as well as additional objects, features and advantages of the invention will be more readily apparent from the following detailed description, which proceeds with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. **1** is a schematic view of a conventional LCD.

[0019] FIG. **2**A is a schematic view of an approach for cutting a raw film to form reflective polarizers.

[0020] FIG. **2**B is a schematic view of another approach for cutting a raw film to form reflective polarizers.

[0021] FIG. **3** is a schematic view showing interactions between a half-wave plate and light.

[0022] FIG. **4** is a schematic view of an embodiment of the LCD of the invention.

[0023] FIG. **5** is a schematic view showing the positional relationship of the bottom polarizer, top polarizer, liquid crystal cell, reflective polarizer and half-wave plate.

[0024] FIG. **6**A is a schematic view of a half-wave plate formed by stacking N sets of ½N wave plates.

[0025] FIG. **6**B is a schematic view of a half-wave plate formed by stacking two sets of quarter-wave plates.

[0026] FIG. **6**C is a schematic view of a half-wave plate formed by stacking four sets of eighth-wave plates.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0027] To facilitate discussion of the embodiments below, the operation principle of the half-wave plate is first explained as follow. When light passes through a half-wave plate the travel distance along a slow axis is less than along a fast axis by one half wavelength. Referring to FIG. **3** for interactions of a half-wave plate and light. The half-wave plate **2160** is made from a birefringent material. The birefringent material has a characteristic: polarized light has a different refraction index in the direction of the different principle axes. Moreover, for the polarized light that has a smaller refractive index in the direction of a selected principle axis, light travels at a faster speed. That selected principle axis is called a fast axis F. On the other hand, the polarized light has a greater refractive index when a principle axis is orthogonal to the fast axis, and the light travels at a lower speed. Hence the principle axis orthogonal to the fast axis is called a slow axis S. Referring to FIG. **3**, if the fast axis F is taken as a reference axis, the polarized direction of light L and the fast axis F form an included angle θ. Hence the light L has a first light component LF on the fast axis F, and a second light component LS on the slow axis S. As the speed of light LF is faster than light LS , when the light L passes through the half-wave plate **2160** the first light component LF travels at a longer distance than the second light component LS by one half wavelength B. Hence the polarized direction of the light L passing through the half-wave plate **2160** forms an included angle $-\theta$ with the fast axis F. As a result, after the light L has passed through the half-wave plate **2160** the polarized direction turns **20**. If the slow axis S is taken as the reference axis, two times of tuning angle also is formed.

[0028] Refer to FIG. **4** for an embodiment of the LCD of the invention. The LCD **2000** includes a backlight module **2100** and a liquid crystal panel **2200**. The backlight module **2100** includes a casing **2110**, a plurality of lamps **2120**, a diffusion plate **2130**, a BEF **2140**, a reflective polarizer **2150** and a half-wave plate **2160**. The lamps **2120** are located in troughs **2112** formed on the casing **2110** with the surface coated with a reflective material. The diffusion plate **2130** contains a plurality of diffusion particles. The BEF **2140** has a plurality of prism-shaped structures **2142** located at an upper side thereof. The reflective polarizer **2150** is located on the BEF **2140** and formed by stacking a plurality of films. A polarized light in the same direction of the transmission axis of the reflective polarizer **2150** can pass through the reflective polarizer **2150**, while the polarized light in the perpendicular direction of the transmission axis of the reflective polarizer **2150** is reflected by the reflective polarizer **2150**.

[0029] The LCD **2200** is a TN type, and includes a bottom polarizer **2210**, a top polarizer **2210'**, a bottom glass substrate **2220**, a top glass substrate **2220'**, a top alignment film **2230**, a bottom alignment film **2230'** and a liquid crystal layer **2240**. The bottom glass substrate **2220**, top glass substrate **2220'**, top alignment film **2230**, bottom alignment film **2230'** and liquid crystal layer **2240** are coupled together to form a liquid crystal cell **2205**.

[0030] Refer to FIG. **5** for the positional relationship of the bottom polarizer, top polarizer, liquid crystal cell, reflective polarizer and half-wave plate. The top polarizer **2210'** has a transmission axis P_2 crosses with a transmission axis P_1 of the bottom polarizer **2210** in an orthogonal manner, namely differ by an angle of 90. In the liquid crystal cell **2205** the laid direction A_1 of liquid crystal molecules at the top layer is same as the direction of the transmission axis P_2 of the top polarizer **2210'**, while the inclined direction A_0 of liquid crystal molecules at the bottom layer is same as the direction of the transmission axis P_1 of the bottom polarizer **2210**.

[0031] Moreover, the fast axis F of the half-wave plate **2160** and the transmission axis P_1 of the bottom polarizer **2210** differ for a first angle θ_1, while the transmission axis P_0 of the reflective polarizer **2150** and the transmission axis P_1 of the bottom polarizer **2210** differ for a second angle θ_2. The first angle θ_1 is one half of the second angle θ_2. In this embodiment the second angle θ_2. is $\pi/4$, while the first angle θ_1 is $\pi/8$.

[0032] Light L_0 emitted from the lamps **2120** (referring to FIG. **3**) projects to the reflective polarized **2150** and generates reactions therewith, in which a second light L_2 with a polarized direction same as the direction of the transmission axis P_0 passes through the reflective polarizer **2150**, while a first light L_1 with a polarized direction different from the direction of the transmission axis P_0 is reflected by the reflective polarizer **2150**. Moreover, as shown in FIG. **3**, when the second light L_2 has passed through the half-wave plate **2160**, the polarized direction turns $2\theta_1$, namely θ_2. Hence a third light L_3 is formed with a polarized direction same as the direction of the transmission axis P_1. As a result the third light L_3 can pass through the bottom polarizer **2210** to reach the liquid crystal cell **2205**.

[0033] Thus after the second light L_2 has passed through the half-wave plate **2160**, the third light L_3 is formed with the polarized direction same as the direction of the transmission axis P_1. Hence the transmission axis P_0 of the reflective polarizer **2150** and the transmission axis P_1 of the bottom polarizer **2210** do not have to be maintained in the same direction. As a result, during fabrication of the reflective polarizer **2150** for the TN type liquid crystal panel, the cutting approach can adopt the one shown in FIG. **2**A without producing scraps, therefore the cost can be reduced.

[0034] In the embodiment previously discussed, the second angle θ_2. is $\pi/4$, and the first angle θ_1 is $\pi/8$. However, when the second angle θ_2 between the transmission axis P_0 of the reflective polarizer **2150** and the transmission axis P_1 of the bottom polarizer **2210** is altered, adjusting the first angle θ_1 between the fast axis F of the half-wave plate **2160** and the transmission axis P_1 of the bottom polazer **2210** also allows the light passing through the half-wave plate **2160** to pass through the bottom polarizer **2210**. This can be easily seen by those skilled in the art.

[0035] The half-wave plate **2160** previously discussed may be fabricated integrally, also may be formed by stacking N sets of ½N wave plates **2162** (referring to FIG. **6**A), where N is a natural number, and the ½N wave plates means that when light passes through the ½N wave plates its travel distance along the slow axis is longer than along the fast axis by ½N wavelength. FIG. **6**B illustrates another embodiment in which the half-wave plate **2160** is formed by stacking two pieces of quarter-wave plates **2164**, and FIG. **6**C illustrates yet another embodiment in which the half-wave plate **2160** is formed by stacking four pieces of eighth-wave plates **2166**.

[0036] While the preferred embodiments of the invention have been set forth for the purpose of disclosure, modifications of the disclosed embodiments of the invention as well as other embodiments thereof may occur to those skilled in the art. Accordingly, the appended claims are intended to cover all embodiments which do not depart from the spirit and scope of the invention.

I claim:

1. An optical film installed on a liquid crystal panel which has a bottom polarizer, comprising:

a reflective polarizer; and

a half-wave plate located on the reflective polarizer, the half-wave plate having a principle axis which differs from a transmission axis of the bottom polarizer for a first angle; the reflective polarizer having another transmission axis differs from the transmission axis of the bottom polarizer for a second angle the first angle being one half of the second angle.

2. The optical film of claim **1**, wherein the second angle is $\pi/4$.

3. The optical film of claim **1**, wherein the half-wave plate is formed by stacking N pieces of ½N wave plates.

4. The optical film of claim **3**, wherein N=2.

5. The optical film of claim **3**, wherein N=4.

6. A liquid crystal display, comprising:

a twisted nematic type liquid crystal panel which includes a bottom polarizer, a liquid crystal cell and a top polarizer, the liquid crystal cell being located between the bottom polarizer and the top polarizer; and

a backlight module which includes a reflective polarizer and a half-wave plate located on the reflective polarizer, the half-wave plate having a principle axis and the bottom polarizer having a transmission axis that differs for a first angle; the reflective polarizer having another transmission axis which differs from the transmission axis of the bottom polarizer for a second angle, the first angle being one half of the second angle.

7. The liquid crystal display of claim **6**, wherein the second angle is $\pi/4$.

8. The liquid crystal display of claim **6**, wherein the half-wave plate is formed by stacking N pieces of ½N wave plates.

9. The liquid crystal display of claim **8**, wherein N=2.

10. The liquid crystal display of claim **8**, wherein N=4.

* * * * *

patsnap

专利名称(译)	光学薄膜和液晶显示器		
公开(公告)号	US20090073353A1	公开(公告)日	2009-03-19
申请号	US11/854595	申请日	2007-09-13
[标]申请(专利权)人(译)	余梁斌 超毅HAN		
申请(专利权)人(译)	郁亮-BIN 超毅-HAN		
当前申请(专利权)人(译)	郁亮-BIN 超毅-HAN		
[标]发明人	YU LIANG BIN CHAO YI HAN		
发明人	YU, LIANG-BIN CHAO, YI-HAN		
IPC分类号	G02F1/1335		
CPC分类号	G02F1/13362		
外部链接	Espacenet USPTO		

摘要(译)

提供光学膜和液晶显示器。液晶显示器包括扭曲向列型液晶面板和背光模块。液晶面板包括底部偏光器，液晶单元和顶部偏光器。液晶盒放置在底部偏振器和顶部偏振器之间。背光源包括反射偏振器和半波片，半波片放置在反射偏振器上。底部偏振器的透射轴和底部偏振器的主轴不同第一角度。底部偏振器和反射偏振器的透射轴不同于第二角度。第一个角度是第二个角度的一半。