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(54) LIQUID CRYSTAL DISPLAY

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(57) ABSTRACT

A liquid crystal display (1) includes an array substrate (11), a liquid crystal layer (12), and a counter substrate (13). The array substrate has optical sensors (1112) to detect light from an object presented in front of the array substrate. The counter electrode has a color filter (132) to transmit light emitted from a light source (14), a transparent electrode (134*a*) that faces a first plurality of pixel electrodes (113) and transmits the light transmitted through the color filter, and a reflective electrode (135) that faces a second plurality of pixel electrodes (113) and reflects external light. The light from the object to be detected is directly given to the optical sensors, which can therefore correctly detect the object. The light emitted from the light source and transmitted through the transparent electrode and the external light reflected from the reflective electrode realize transmissive display and reflective display.

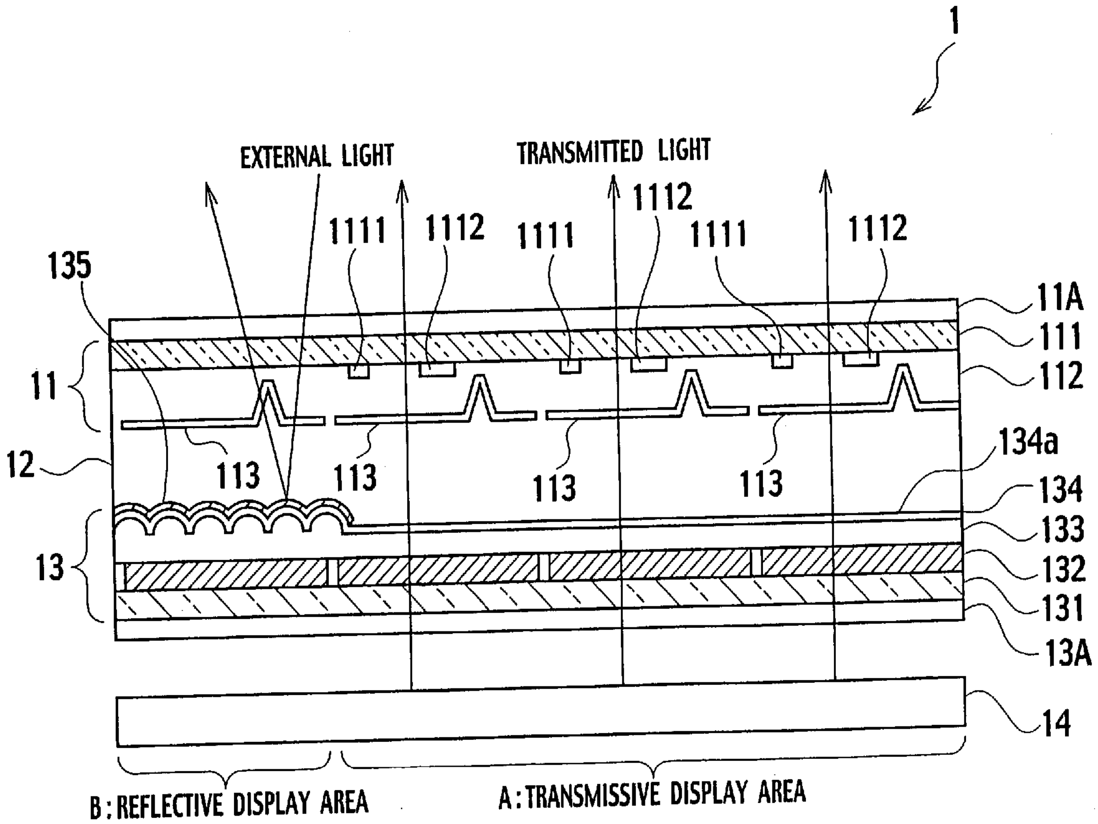
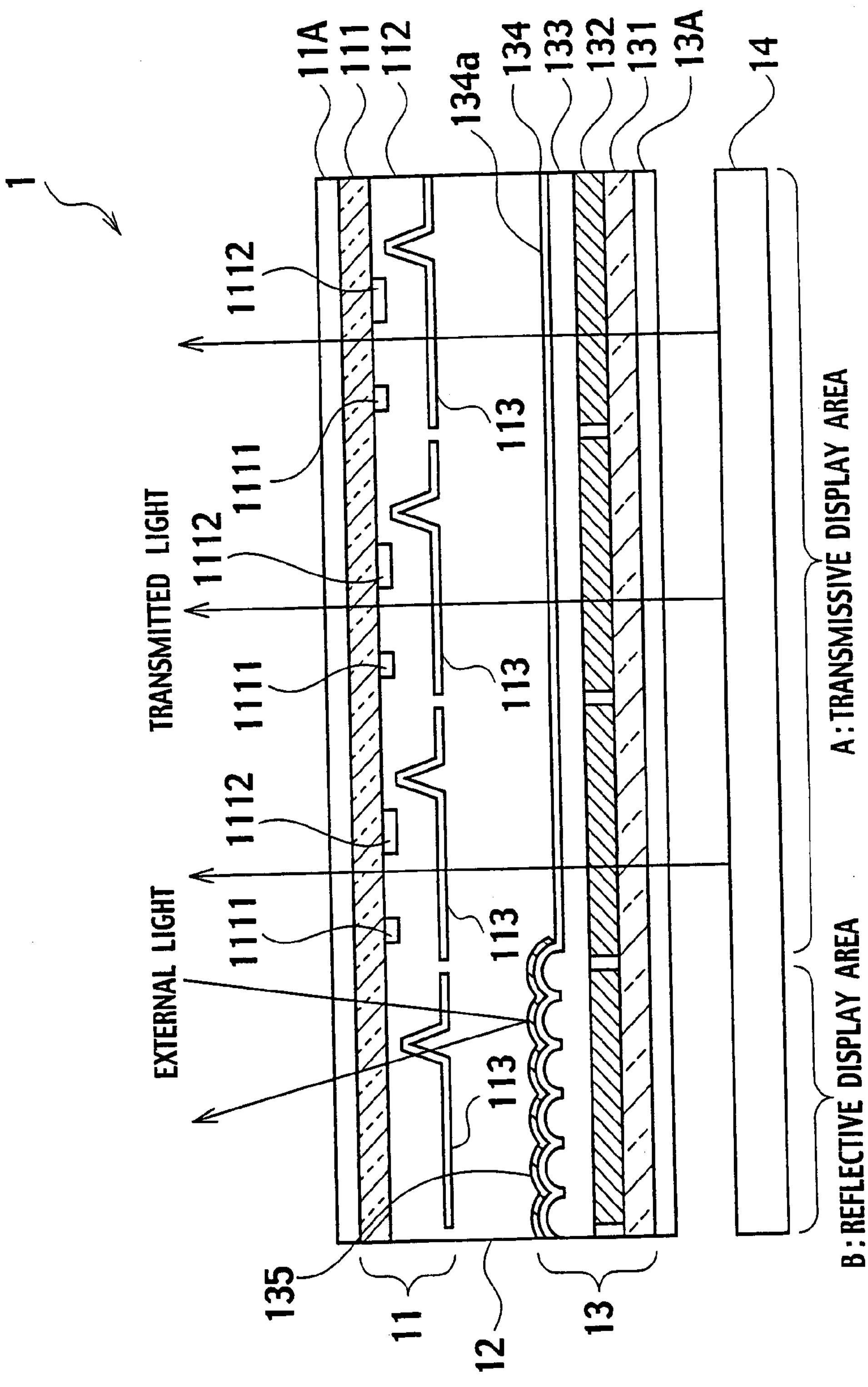
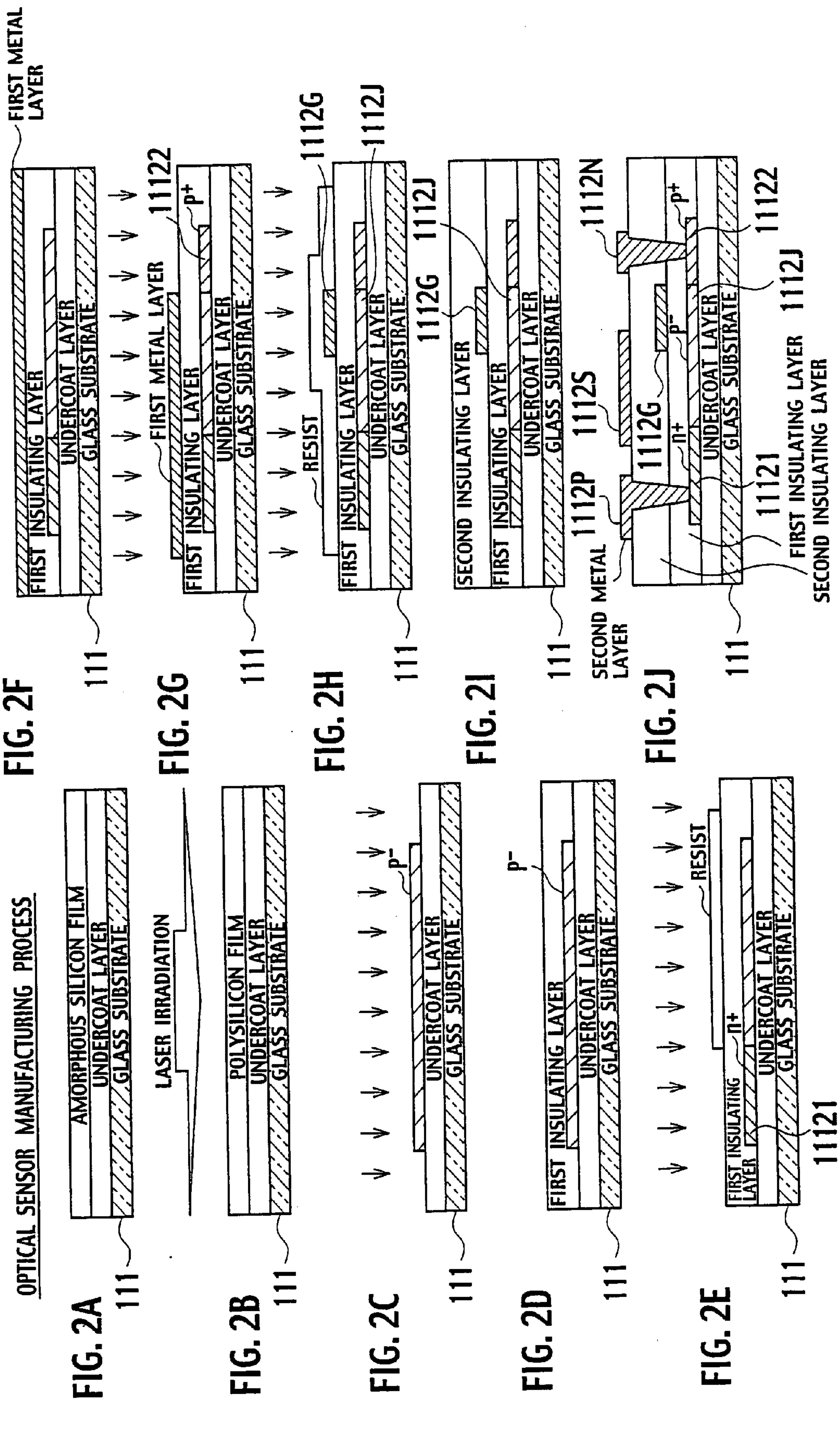
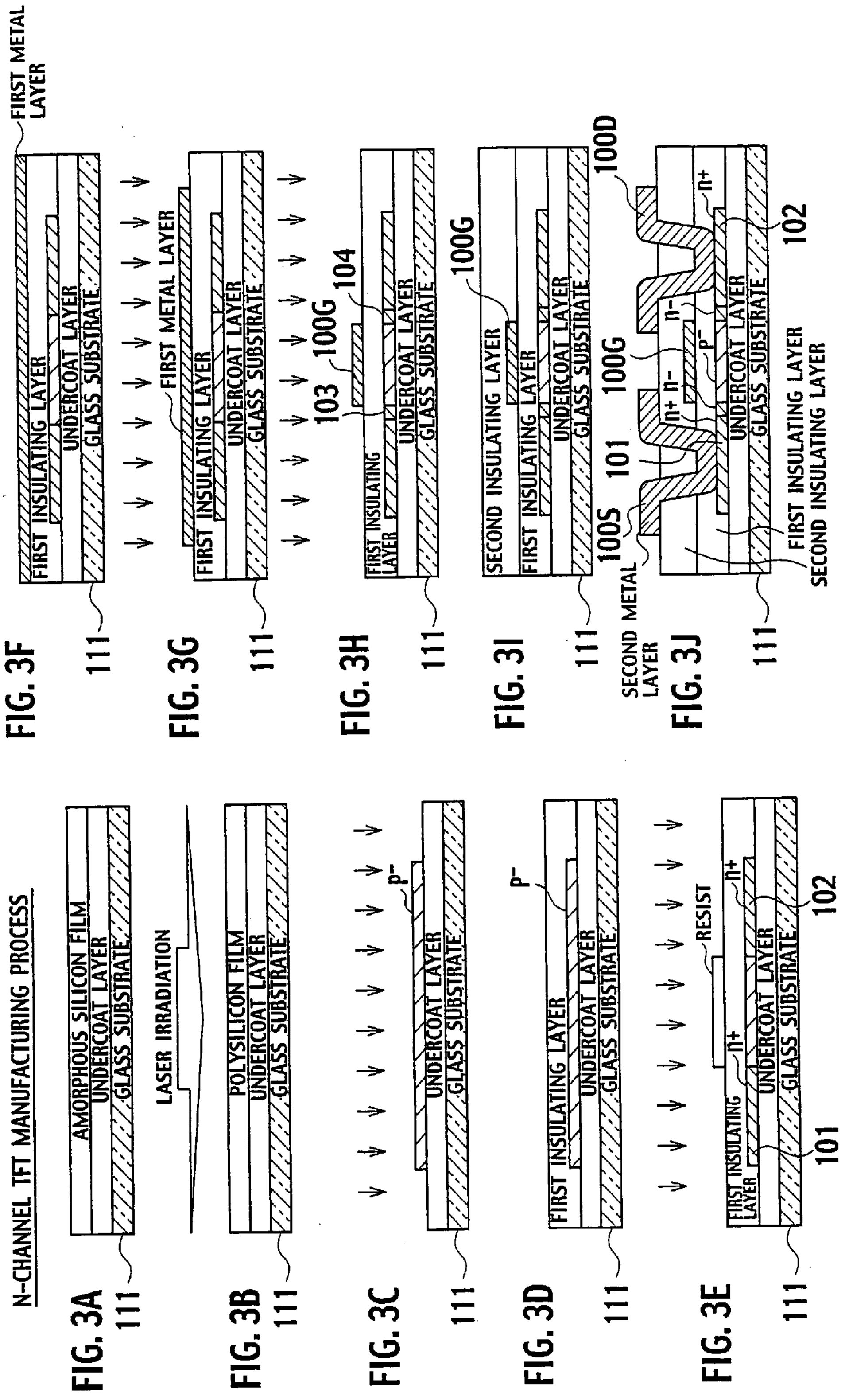


FIG. 1


1
11A
111
112
134a
134
133
132
131
13A
14
1112
1111
113
TRANSMITTED LIGHT
EXTERNAL LIGHT
135
11
12
13
A: TRANSMISSIVE DISPLAY AREA
B: REFLECTIVE DISPLAY AREA


OPTICAL SENSOR MANUFACTURING PROCESS
FIG. 2A
AMORPHOUS SILICON FILM
UNDERCOAT LAYER
GLASS SUBSTRATE
111
LASER IRRADIATION
FIG. 2B
POLYSILICON FILM
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 2C
p−
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 2D
p−
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 2E
RESIST
n+
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
11121
111
FIG. 2F
FIRST METAL LAYER
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 2G
11122
p+
FIRST METAL LAYER
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 2H
1112G
1112J
RESIST
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 2I
1112J
1112G
SECOND INSULATING LAYER
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 2J
1112N
1112P
1112S
1112G
p+
p−
n+
11122
1112J
11121
UNDERCOAT LAYER
GLASS SUBSTRATE
SECOND METAL LAYER
FIRST INSULATING LAYER
SECOND INSULATING LAYER
111


N-CHANNEL TFT MANUFACTURING PROCESS
FIG. 3A
AMORPHOUS SILICON FILM
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 3B
LASER IRRADIATION
POLYSILICON FILM
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 3C
p⁻
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 3D
p⁻
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 3E
RESIST
n+
n+
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
101
102
111
FIG. 3F
FIRST METAL LAYER
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 3G
FIRST METAL LAYER
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 3H
103
100G
104
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 3I
100G
SECOND INSULATING LAYER
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 3J
SECOND METAL LAYER
100S
101
100G
100G
100D
n+ n-
p⁻
n-
n+
102
UNDERCOAT LAYER
GLASS SUBSTRATE
FIRST INSULATING LAYER
SECOND INSULATING LAYER
111

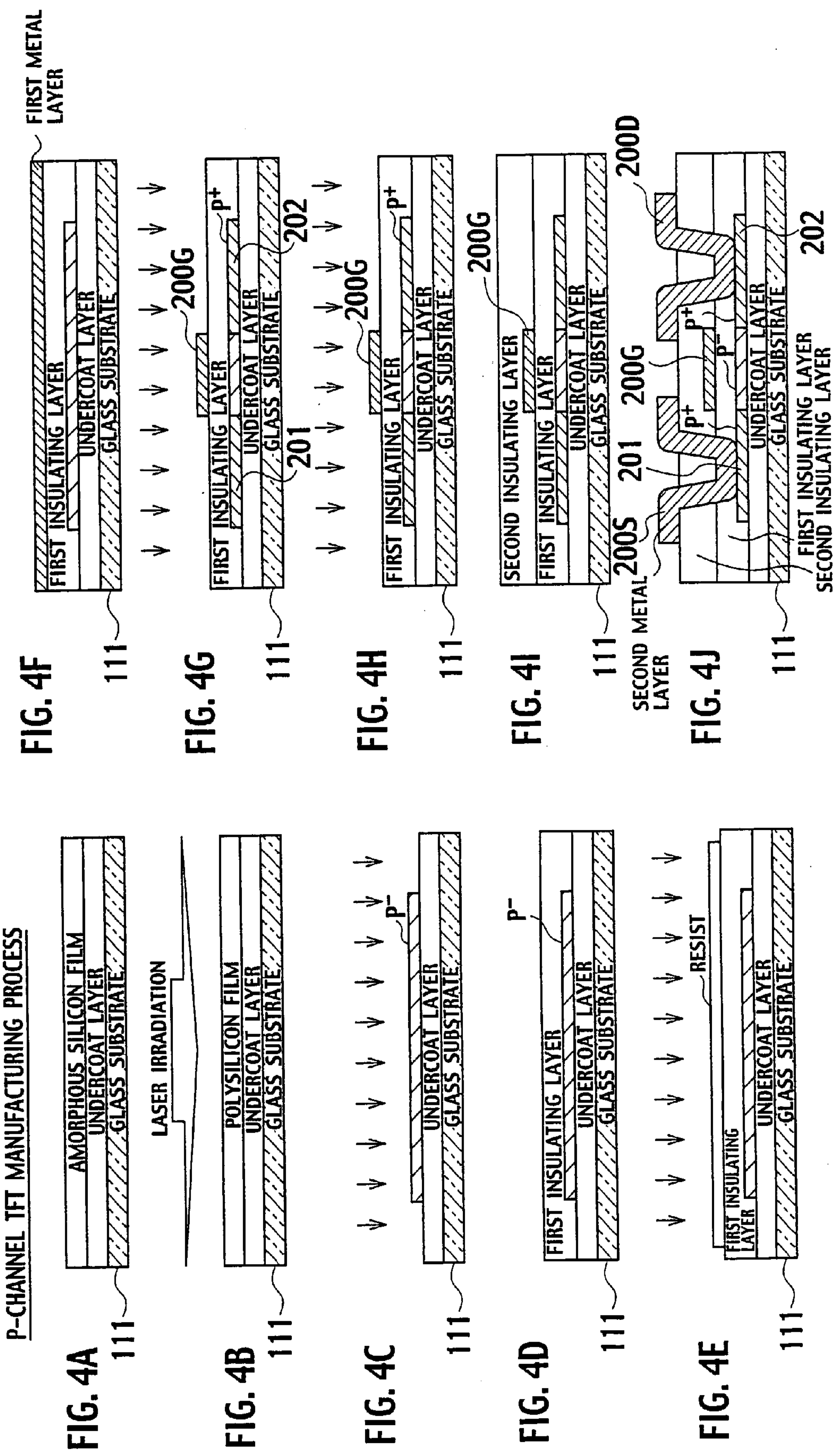
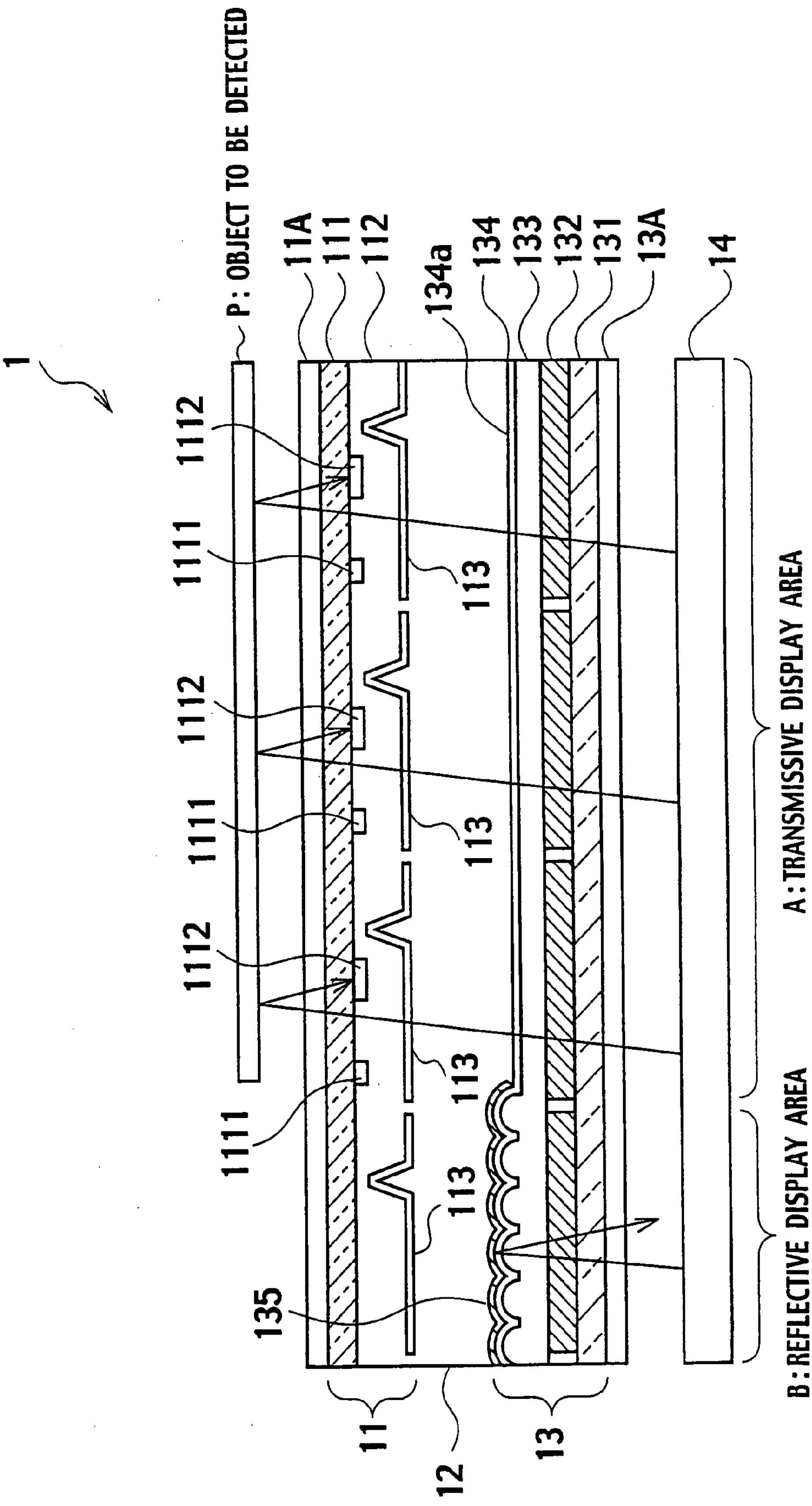

P-CHANNEL TFT MANUFACTURING PROCESS
FIG. 4A
AMORPHOUS SILICON FILM
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 4B
LASER IRRADIATION
POLYSILICON FILM
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 4C
P−
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 4D
P−
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 4E
RESIST
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 4F
FIRST METAL LAYER
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 4G
200G
P+
202
201
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 4H
200G
P+
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 4I
200G
SECOND INSULATING LAYER
FIRST INSULATING LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
111
FIG. 4J
200D
202
P+
P−
200G
P+
201
200S
SECOND METAL LAYER
UNDERCOAT LAYER
GLASS SUBSTRATE
FIRST INSULATING LAYER
SECOND INSULATING LAYER
111

FIG. 5



P: OBJECT TO BE DETECTED
1
11A
111
112
134a
134
133
132
131
13A
14
1112
1111
1112
1111
1112
1111
113
113
113
113
135
11
12
13
A: TRANSMISSIVE DISPLAY AREA
B: REFLECTIVE DISPLAY AREA

LIQUID CRYSTAL DISPLAY

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2004-213268, filed on Jul. 21, 2004. The entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a liquid crystal display capable of correctly detecting an object and conducting transmissive display as well as reflective display.

[0004] 2. Description of Related Art

[0005] Liquid crystal displays (LCDs) are thin, lightweight, and low in power consumption, and therefore, are widely used for cellular phones, smart-phones, PDAs (personal digital assistants), personal computers, and the like.

[0006] The LCD has an array substrate on which scanning lines and signal lines cross each other, a counter substrate, a liquid crystal layer held between the array substrate and the counter substrate, and a drive circuit for driving the scanning lines and the signal lines. A pixel is formed at each crossing portion of the scanning lines and the signal lines. A video signal is applied to the pixels, to change the light transmittance of the liquid crystal layer and display an image.

[0007] Among LCDs, those having light sources are in the mainstream because they can display images in the dark.

[0008] To make the LCD compact and low in cost, recent technology integrates the drive circuit into the array substrate containing pixels, each pixel having a switching element (such as a TFT (thin film transistor)) and a pixel electrode.

[0009] Some recent LCDs incorporate detective elements such as optical sensors to realize a scanning function.

[0010] The LCD having the scanning function emits light from a light source. The light is transmitted through the LCD and is reflected from a detection object such as a printed object. The intensity of the reflected light is detected by the optical sensors of the LCD and is used to provide an image of the object.

[0011] The optical sensors incorporated in the LCD may detect the intensity of light emitted from a light pen, to realize a light-pen input function. Instead of the optical sensors, other elements such as piezoelectric elements may be employed to realize a touch-panel function.

[0012] The detective elements such as the optical sensors and piezoelectric elements are formed on the array substrate so that the detective elements and TFTs serving as switching elements may be formed through common processes. This can reduce the number of manufacturing processes of the LCD. The light source is arranged behind the counter substrate of the LCD. This arrangement allows a detection object to be presented in front of the array substrate so that the detective elements may correctly detect light or pressure provided by the object.

[0013] To reduce power consumption, some recent LCDs conduct as a transmissive display with light emitted from a light source and also as a reflective display with external light to display, for example, the date and time. Such LCDs employ reflective electrodes for some pixel electrodes arranged on the array substrate.

[0014] There is a requirement for an LCD that is capable of providing the detective function and the transmissive-reflective display function.

[0015] Simply combining the structures of the two types of LCD by forming detective elements and reflective electrodes on an array substrate is unsatisfactory because the combination will transmit no external light through a liquid crystal layer. Then, the LCD is unable to control brightness and achieve reflective display.

[0016] An example of the related arts mentioned above is disclosed in Japanese Unexamined Patent Application Publication No. 2002-303863.

SUMMARY OF THE INVENTION

[0017] An object of the present invention is to provide a liquid crystal display (LCD) capable of correctly detecting a detection object and conducting transmissive display as well as reflective display.

[0018] In order to accomplish the object, a first aspect of the present invention provides an LCD having an array substrate provided with a plurality of scanning lines and a plurality of signal lines that cross the scanning lines, a counter substrate, and a liquid crystal layer held between the array substrate and the counter substrate. A pixel is formed at each crossing portion of the scanning lines and the signal lines. The array substrate includes transparent pixel electrodes and detective elements. The pixel electrodes are provided for the pixels, respectively, to apply an electric field to the liquid crystal layer. The detective elements detect an object presented in front of the array substrate. The counter substrate includes a color filter to transmit light emitted from a light source that is arranged behind the counter substrate, a transparent electrode facing a first plurality of the pixel electrodes, to transmit the light transmitted through the color filter, and a reflective electrode facing a second plurality of the pixel electrodes, to reflect external light.

[0019] According to the first aspect, the array substrate of the LCD has the detective elements to detect an object presented in front of the array substrate. The counter substrate has the color filter that faces the first plurality of pixel electrodes and transmits light emitted from the light source, and the reflective electrode that faces the second plurality of pixel electrodes and reflects external light. The detection object is directly presented to the detective elements, so that the detective elements correctly detect the object. The light emitted from the light source and transmitted through the transparent electrode and the external light reflected from the reflective electrode are both transmitted through the liquid crystal layer, to thereby realize transmissive display as well as reflective display.

[0020] According to a second aspect of the present invention, the reflective electrode of the LCD of the first aspect has irregularities.

[0021] According to the second aspect, the reflective electrode of the LCD has irregularities to scatter light reflected from the reflective electrode, to increase the view angle.

[0022] According to a third aspect of the present invention, the reflective electrode of the LCD of any one of the first and second aspects is arranged on the liquid crystal layer side of the color filter.

[0023] According to the third aspect, the reflective electrode of the LCD is arranged on the liquid crystal layer side of the color filter, so that no external light is transmitted through the color filter under the reflective electrode, to thereby realize monochromatic reflective display.

[0024] In this way, the LCD according to the present invention includes the array substrate having the detective elements to detect an object presented in front of the array substrate. The counter electrode of the LCD includes the color filter to transmit light emitted from the light source, the transparent electrode that faces the first plurality of pixel electrodes and transmits the light transmitted through the color filter, and the reflective electrode that faces the second plurality of pixel electrodes and reflects external light. The detection object is directly presented to the detective elements, so that the detective elements may correctly detect the object. The light emitted from the light source and transmitted through the transparent electrode and the external light reflected from the reflective electrode are both transmitted through the liquid crystal layer, to thereby realize transmissive display as well as reflective display.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] **FIG. 1** is a sectional view partly showing an LCD **1** according to an embodiment of the present invention;

[0026] **FIGS. 2A** to **2J** are sectional views showing, in particular, an optical sensor **1112** in a series of processes for forming the optical sensor **1112**, an n-channel TFT **100**, and a p-channel TFT **200** on an array substrate **11**;

[0027] **FIGS. 3A** to **3J** are sectional views showing, in particular, the n-channel TFT **100** in the series of forming processes;

[0028] **FIGS. 4A** to **4J** are sectional views showing, in particular, the p-channel TFT **200** in the series of forming processes; and

[0029] **FIG. 5** is a sectional view similar to **FIG. 1**, showing a detective operation of the LCD **1**.

DETAILED DESCRIPTION OF EMBODIMENT

[0030] A liquid crystal display (LCD) according to an embodiment of the present invention will be explained.

[0031] **FIG. 1** is a sectional view partly showing the LCD **1** according to an embodiment of the present invention.

[0032] The LCD **1** has an array substrate **11** on which a plurality of scanning lines (not shown) and a plurality of signal lines (not shown) are formed. The scanning lines and the signal lines cross each other. The array substrate **11** faces a counter substrate **13**, and a liquid crystal layer **12** is held between the array substrate **11** and the counter substrate **13**.

[0033] In the LCD **1**, red (R), green (G), and blue (B) pixels are regularly arranged at crossing portions of the scanning lines and the signal lines, respectively. An image displayed with the pixels is viewed in front of the array substrate **11**. Behind the counter substrate **13**, there is a surface light source **14**.

[0034] The number of the signal lines is, for example, 240 for each of the R, G, and B colors. The number of the scanning lines is, for example, 320. Then, the number of pixels formed at the crossing portions of the signal and scanning lines will be about 230,000 to realize a QVGA (quarter video graphics array) display. All pixels may be arranged in a display area having a 2.2-inch diagonal size. With this size, a pixel pitch in a horizontal scanning direction is about 50 μm, a pixel pitch in a vertical scanning direction is about 150 μm, and a distance (cell gap) between the array substrate **11** and the counter substrate **13** is about 5 μm.

[0035] The LCD **1** has a transmissive display area A that allows light from the light source **14** to be transmitted through the liquid crystal layer **12** and a reflective display area B that reflects external light. The transmissive display area A may involve a majority of the pixels of the whole display area, and the reflective display area B involves the remaining pixels.

[0036] The array substrate **11** has a transparent glass substrate **111** of, for example, 0.7 mm thick. Each pixel region of the glass substrate **111** includes a switching element **1111** connected to a signal line (not shown) and a scanning line (not shown). On the liquid crystal layer **12** side of the glass substrate **111**, there is a transparent resin layer **112** through which each switching element **1111** is connected to a transparent pixel electrode **113** made of, for example, ITO (indium tin oxide). The signal lines are connected to a signal line driver (not shown), and the scanning lines are connected to a scanning line driver (not shown).

[0037] Each pixel region in the transparent display area A of the array substrate **11** has an optical sensor **1112** that is connected to a detective circuit (not shown).

[0038] The counter substrate **13** has a glass substrate **131**. The whole display area of the glass substrate **131** on the liquid crystal layer **12** side is covered with a color filter **132**.

[0039] The color filter **132** is provided with a lattice-like light shield film made of resin. The color filter **132** of a specific color is arranged in each pixel region encircled by the signal lines and the scanning lines.

[0040] The whole display area of the color filter **132** of the counter substrate **13** is covered with a transparent resin layer **133**. In the transparent display area A, the transparent resin layer **133** is flat, and in the reflective display area B, it is irregular.

[0041] The whole display area of the transparent resin layer **133** is covered with a transparent electrode **134** made of, for example, ITO. Corresponding to the shape of the transparent resin layer **133**, the electrode **134** has irregularities in the reflective display area B.

[0042] The reflective display area B on the transparent electrode **134** is covered with an opaque reflective electrode **135** made of, for example, aluminum, to reflect external light. Corresponding to the irregular shape of the electrode **134**, the reflective electrode **135** has irregularities.

[0043] The transparent display area A on the transparent electrode **134** serves as a transparent electrode **134***a* that is flat.

[0044] The transparent electrode **134***a* and reflective electrode **135** are covered with an orientation film that has been rubbed to provide the liquid crystal layer **12** with a pre-tilt of, for example, 6° in a predetermined direction.

[0045] On the light source **14** side, the counter substrate **13** has a polarizing plate **13**A. On the front side of the array substrate **11**, there is a polarizing plate **11**A.

[0046] **FIGS. 2A** to **4**J show a series of processes for forming, on the array substrate **11**, the optical sensors **1112**, n-channel TFTs **100** serving as the switching elements **1111**, and p-channel TFTs **200** that form a drive circuit. These processes may involve a polysilicon process. Among **FIGS. 2A** to **4**J, **FIGS. 2A** to **2**J show a part of the array substrate **11** where the optical sensor **1112** is formed, **FIGS. 3A** to **3**J show a part of the array substrate **11** where the n-channel TFT **100** is formed, and **FIGS. 4A** to **4**J show a part of the array substrate **11** where the p-channel TFT **200** is formed.

[0047] Now, the series of processes for forming the optical sensors **1112**, n-channel TFTs **100**, and p-channel TFTs **200** on the array substrate **11** will be explained.

[0048] In **FIGS. 2A, 3A**, and **4A**, an undercoat layer is formed on a glass substrate **111** from SiNx (silicon nitride) or SiOx (silicon oxide) by CVD (chemical vapor deposition). The undercoat layer prevents impurities such as phosphor and boron from diffusing to the glass substrate **111**. Over the undercoat layer, amorphous silicon is deposited to about 50 angstroms by PECVD (plasma enhanced chemical vapor deposition) or spattering, to form an amorphous silicon film.

[0049] In **FIGS. 2B, 3B**, and **4B**, a laser beam is emitted to the amorphous silicon film, to crystallize the amorphous silicon film into a polysilicon film.

[0050] In **FIGS. 2C, 3C**, and 4C, low-concentration boron ions are implanted into the whole surface of the polysilicon film. A mask is formed on the polysilicon film, and the polysilicon film is exposed and etched to form a p^- layer.

[0051] In **FIGS. 2D, 3D**, and 4D, an SiOx film serving as a first insulating layer is formed by, for example, PECVD.

[0052] In **FIGS. 2E, 3E**, and **4E**, a resist mask is formed, and high-concentration phosphor ions are implanted into an n-type electrode region **11121** of each optical sensor **1112** and a source region **101** and drain region **102** of each n-channel TFT **100**, to form an n^+ layer.

[0053] In **FIGS. 2F, 3F**, and **4F**, the resist mask is removed, and a first metal layer is formed over the first insulating layer from an Mo (molybdenum)-Ta (tantalum) alloy, an Mo—W (tungsten) alloy, or the like.

[0054] In **FIGS. 2G, 3G**, and **4G**, the semifinished product is patterned to open a p-type electrode region **11122** of each optical sensor **1112** and a source region **201** and drain region **202** of each p-channel TFT **200**. Then, high-concentration boron ions are implanted into the semifinished product.

[0055] At this time, the first metal layer serves as a mask to form a p^+ layer in the p-type electrode region **11122**, source region **201**, and drain region **202**. For the p-channel TFT **200**, the first metal layer patterned at this time forms a gate electrode **200**G.

[0056] In **FIGS. 2H, 3H**, and 4H, the first metal layer is patterned to open a light receiving part **1112**J of each optical sensor **1112** and an n^- region **103** and n^- region **104** of each n-channel TFT **100**. For the n-channel TFT **100**, the first metal layer patterned at this time forms a gate electrode **100**G. For the optical sensor **1112**, the first metal layer patterned at this time forms a gate electrode **1112**G.

[0057] A resist mask is formed over the optical sensors **1112**, and low-concentration phosphor ions are implanted.

[0058] With the first metal layer and resist serving as a mask, an n^- layer is formed in the n^- region **103** and n^- region **104** of each n-channel TFT **100**.

[0059] The light receiving part **1112**J of the optical sensor **1112** is made of a p^- layer, and therefore, the optical sensor **1112** is a PIN-type optical sensor.

[0060] The resist mask is removed. To activate the implanted ions, the semifinished product is annealed at about 500° C. and is exposed to hydrogen plasma for hydrogenation.

[0061] In **FIGS. 2I, 3I**, and 4I, a second insulating layer is formed over the first insulating layer from SiOx by, for example, CVD.

[0062] In **FIGS. 2J, 3J**, **4J**, contact holes are formed to expose the n-type electrode region **11121** and p-type electrode region **11122** of each optical sensor **1112**, the source region **101** and drain region **102** of each n-channel TFT **100**, and the source region **201** and drain region **202** of each p-channel TFT **200**. The exposed parts are covered with a second metal layer, which is patterned to form the p-type electrode **1112**P, n-type electrode **1112**N, and light shield band **1112**S of each optical sensor **1112**, the source electrode **100**S and drain electrode **100**D of each n-channel TFT **100**, and the source electrode **200**S and drain electrode **200**D of each p-channel TFT **200**.

[0063] Returning to **FIG. 1**, a display operation of the LCD **1** will be explained.

[0064] In the LCD **1**, the scanning lines are sequentially driven and switching elements **1111** corresponding to, for example, red (R) pixels to be written with a selected scanning line are driven to be conductive. Then, a video signal supplied to the signal lines is applied to the pixel electrodes **113** of the selected red pixels. At the same time, a predetermined signal is supplied to each of the reflective electrode **135** and transparent electrode **134***a*. This results in applying an electric field to the liquid crystal layer **12** between the pixel electrodes **113** and the reflective electrode **135** and transparent electrode **134***a*. The strength of the electric field is dependent on the amplitude of the video signal and influences the light transmittance of the liquid crystal layer **12**.

[0065] Part of the light emitted from the light source **14** to the transmissive display area A is sequentially transmitted through the polarizing plate **13**A, glass substrate **131**, color filter **132**, transparent resin layer **133**, transparent electrode **134***a,* orientation film (not shown), liquid crystal layer **12**, orientation film (not shown), pixel electrodes **113**, transparent resin layer **112**, glass substrate **111**, and polarizing plate **11A** and is emitted to the outside.

[0066] External light made incident to the reflective display area B is sequentially transmitted through the polarizing plate **11A**, glass substrate **111**, transparent resin layer **112**, pixel electrodes **113**, orientation film (not shown), liquid crystal layer **12**, and orientation film (not shown) and reaches the reflective electrode **135**. The light is reflected from the reflective electrode **135**, is sequentially transmitted through the orientation film (not shown), liquid crystal layer **12**, orientation film (not shown), pixel electrodes **113**, transparent resin layer **112**, glass substrate **111**, and polarizing plate **11A**, and is emitted outside. The reflective electrode **135** has irregularities, and therefore, the reflected light from the reflective electrode **135** scatters.

[0067] By controlling the light transmittance of the liquid crystal layer **12**, the LCD **1** can control the intensity of light emitted from the liquid crystal layer **12**, i.e., the brightness of the pixels to display characters and images.

[0068] Scattering the reflected light from the reflective electrode **135** with the irregularities of the reflective electrode **135** can widen a view angle.

[0069] The reflective electrode **135** is arranged on the liquid crystal layer **12** side of the color filter **132**, so that external light is not transmitted through the color filter **132**. As a result, the reflective display area B can display a monochromatic image.

[0070] With reference to **FIG. 5**, which is a sectional view similar to **FIG. 1**, a detective operation of the LCD **1** will be explained.

[0071] An image signal that has been controlled to equalize the light transmittance of the liquid crystal layer **12** in the transmissive display area A is supplied to the signal lines. Thereafter, an object P such as a printed object to be detected is positioned in front of the transmissive display area A of the array substrate **11**.

[0072] Light emitted from the light source **14** is transmitted through the polarizing plate **13A**, glass substrate **131**, and color filter **132**. Part of the light transmitted through the color filter **132** and reflective display area B is transmitted through the transparent resin layer **133** and is reflected from the reflective electrode **135**.

[0073] The remaining part of the light transmitted through the color filter **132** is sequentially transmitted through the transparent resin layer **133**, transparent electrode **134*a*,** orientation film (not shown), pixel electrodes **113**, transparent resin layer **112**, glass substrate **111**, and polarizing plate **11A** and is transmitted outside. Then, this light is reflected from the detection object P and enters the array substrate **11**. The intensity of the entered light is converted by each optical sensor **1112** into an electronic signal, which is detected by the detective circuit and is used to form an image of the object P.

[0074] As mentioned above, the array substrate **11** of the LCD **1** has the optical sensors **1112** serving as detective elements to detect light from a detection object that is presented in front of the array substrate **11**. The counter substrate **13** has the color filter **132** to transmit light emitted from the light source **14**, the transparent electrode **134*a*** that faces some pixel electrodes **113** and passes the light transmitted through the color filter **132**, and the reflective electrode **135** that faces the remaining pixel electrodes **113** and reflects external light. With this arrangement, light from the detection object is directly given to the optical sensors **1112** serving as detective elements and is properly used to provide a correct image of the object. The light emitted from the light source **14** and transmitted through the transparent electrode **134*a*** and the external light reflected from the reflective electrode **135** are both transmitted through the liquid crystal layer **12**, to realize transmissive display and reflective display.

[0075] The reflective electrode **135** has irregularities to scatter light reflected from the reflective electrode **135**, thereby widening the view angle.

[0076] The reflective electrode **135** is arranged on the liquid crystal layer **12** side of the color filter **132** to prevent external light from entering the color filter **132**. Namely, the reflective electrode **135** realizes monochromatic reflective display.

[0077] In the LCD **1** according to this embodiment, the optical sensors **1112** are provided for the pixels in the transmissive display area A, respectively. Instead, the optical sensors **1112** may be provided for the pixels in the reflective display area B, respectively. Alternatively, the optical sensors **1112** may be provided for the pixels in the transmissive display area A and reflective display area B, respectively. It is also possible to regularly arrange the optical sensors **1112** in a predetermined detective area in the array substrate **11**. The optical sensors **1112** are not limited to the PIN-type sensors. Any other type, for example, PN-type optical sensors are acceptable for the present invention.

[0078] In the LCD **1** according to the present invention, the optical sensors **1112** may detect the intensity of light emitted from a light pen to allow pen input. Instead of the optical sensors **1112**, piezoelectric elements may be employed as pressure detecting elements to realize a touch panel function. The piezoelectric elements provided for the array substrate **11** can correctly detect objective pressure.

[0079] When detecting light from a light pen or pressure from an object, the optical sensors **1112** or piezoelectric elements may be arranged outside the display area of the array substrate **11**.

What is claimed is:

1. A liquid crystal display comprising an array substrate provided with a plurality of scanning lines and a plurality of signal lines that cross the scanning lines, a counter substrate, a liquid crystal layer held between the array substrate and the counter substrate, and pixels formed at crossing portions of the scanning lines and the signal lines, respectively, wherein:

the array substrate includes transparent pixel electrodes and detective elements, the pixel electrodes being provided for the pixels, respectively, to apply an electric field to the liquid crystal layer, the detective elements detecting an object presented in front of the array substrate; and

the counter substrate includes a color filter to transmit light emitted from a light source that is arranged behind the counter substrate, a transparent electrode facing a first plurality of the pixel electrodes, to transmit the light transmitted through the color filter, and a reflective electrode facing a second plurality of the pixel electrodes, to reflect external light.

2. The liquid crystal display of claim 1, wherein the reflective electrode has irregularities.

3. The liquid crystal display of any one of claims **1** and **2**, wherein the reflective electrode is arranged on the liquid crystal layer side of the color filter.

* * * * *

patsnap

专利名称(译)	液晶显示器		
公开(公告)号	US20060017871A1	公开(公告)日	2006-01-26
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[标]申请(专利权)人(译)	东芝松下显示技术股份有限公司		
申请(专利权)人(译)	东芝松下显示技术有限公司.		
当前申请(专利权)人(译)	东芝松下显示技术有限公司.		
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外部链接	Espacenet USPTO		

摘要(译)

液晶显示器（1）包括阵列基板（11），液晶层（12）和对向基板（13）。阵列基板具有光学传感器（1112），以检测来自呈现在阵列基板前方的物体的光。对电极具有：滤色器（132），用于透射从光源（14）发出的光;透明电极（134a），其面对第一多个像素电极（113），并透射透过滤色器的光，以及反射电极（135），其面对第二多个像素电极（113）并反射外部光。来自待检测物体的光直接提供给光学传感器，因此可以正确地检测物体。从光源发出并透过透明电极的光和从反射电极反射的外部光实现透射显示和反射显示。