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(54) **LIQUID CRYSTAL DISPLAY DEVICE WITH SCATTERING LAYER AND FABRICATING METHOD THEREOF**

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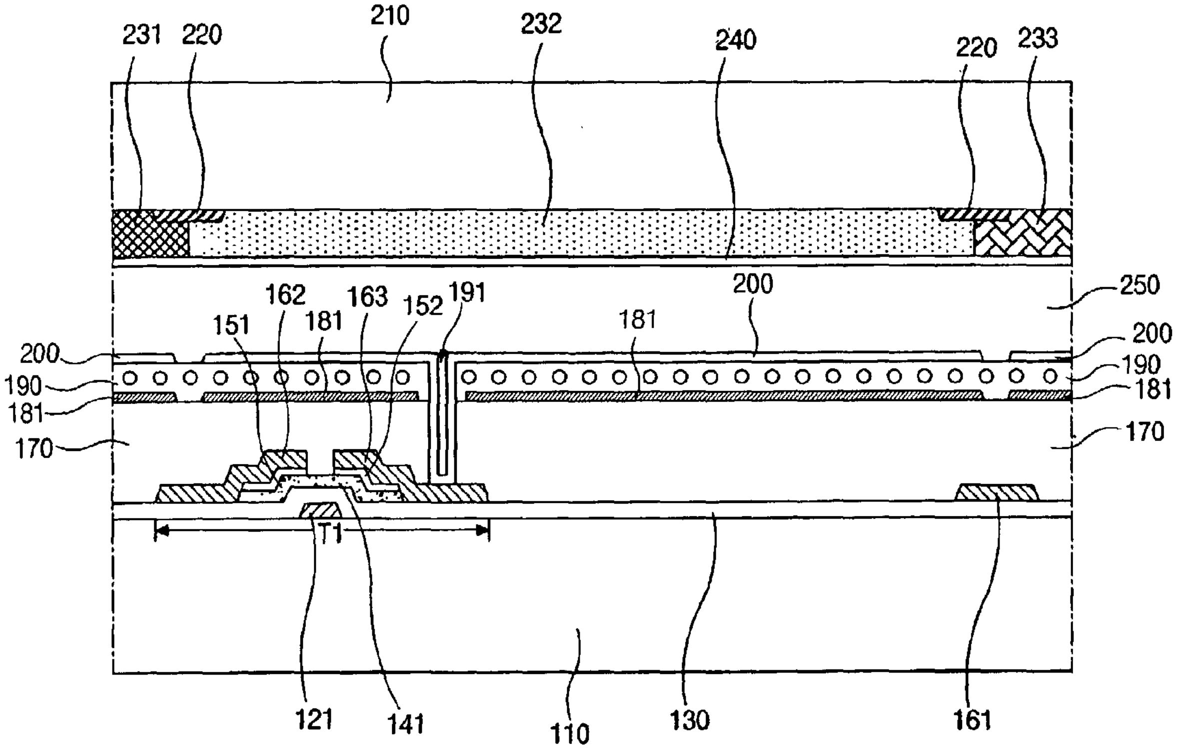
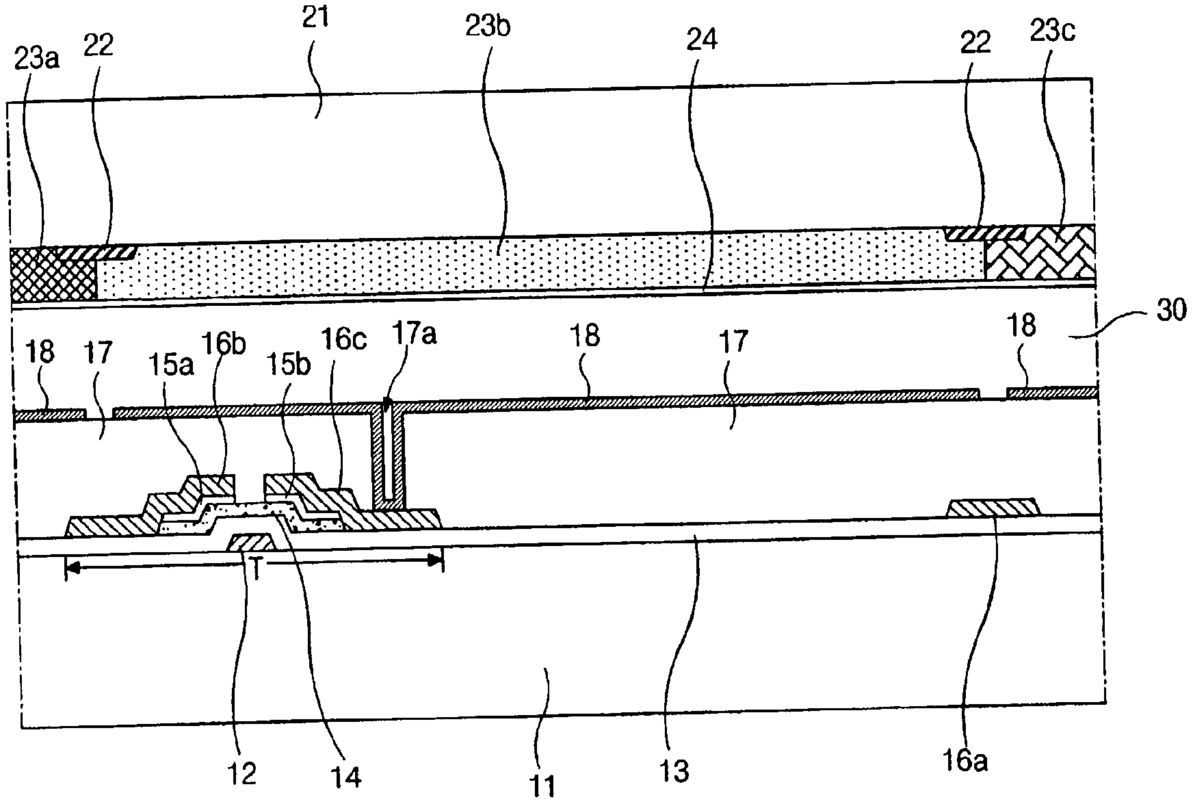
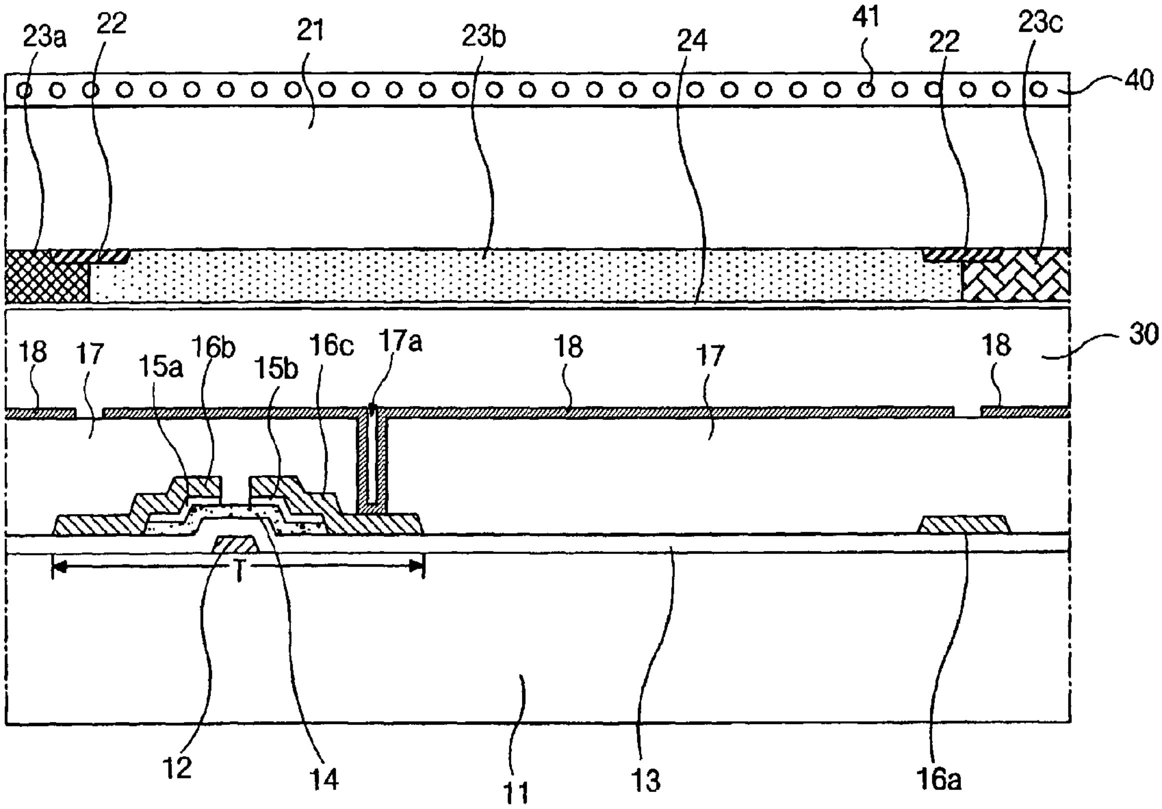
(57) **ABSTRACT**

A reflective liquid crystal display device includes first and second substrates facing and spaced apart from each other. A thin film transistor is connected to a gate line and a data line that define a pixel region, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes. A passivation layer covers the gate line, the data line and the thin film transistor. A reflective plate of an opaque material is formed on the passivation layer at the pixel region. A scattering layer is formed on the reflective plate, the scattering layer having a contact hole exposing the drain electrode through the passivation layer. A pixel electrode of a transparent conductive material is formed on the scattering layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole. A black matrix is formed on an inner surface of the second substrate, the black matrix covering an edge of the pixel electrode. A color filter layer is formed on the black matrix, the color filter layer having red, green and blue colors. A common electrode is formed on the color filter layer. A liquid crystal layer is interposed between the pixel electrode and the common electrode.



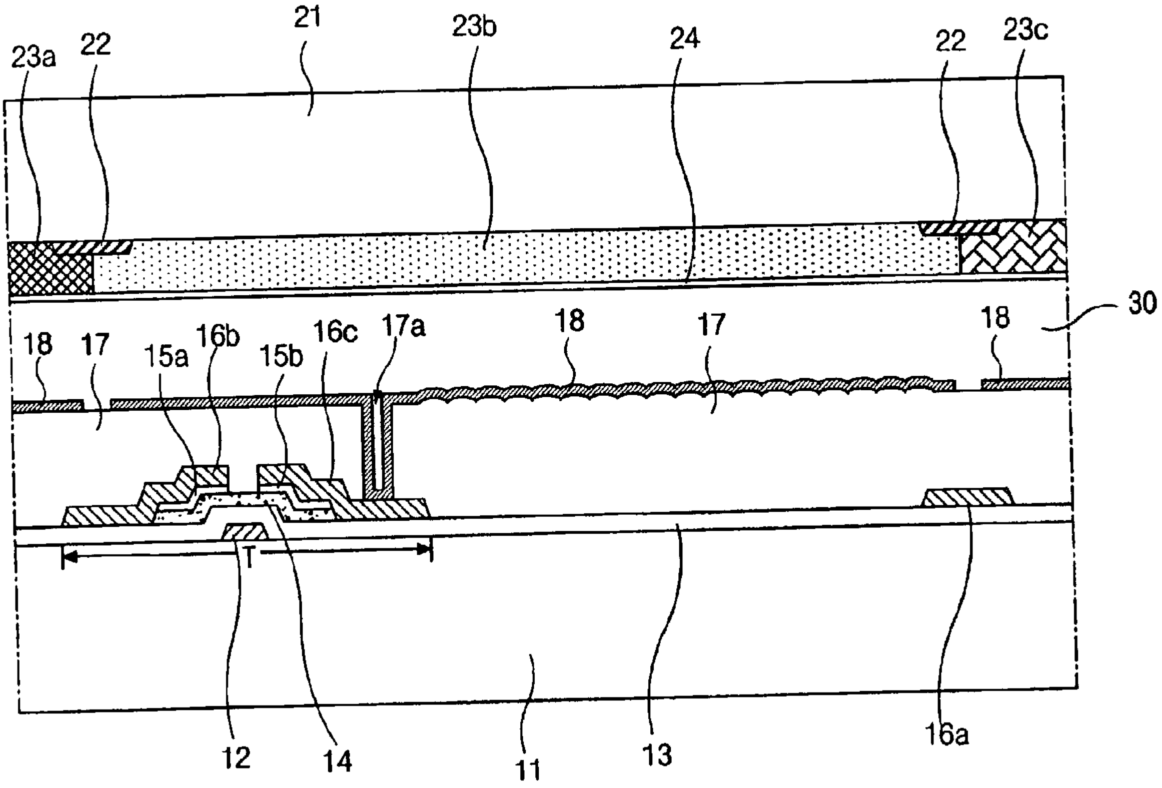


(related art)
FIG. 1

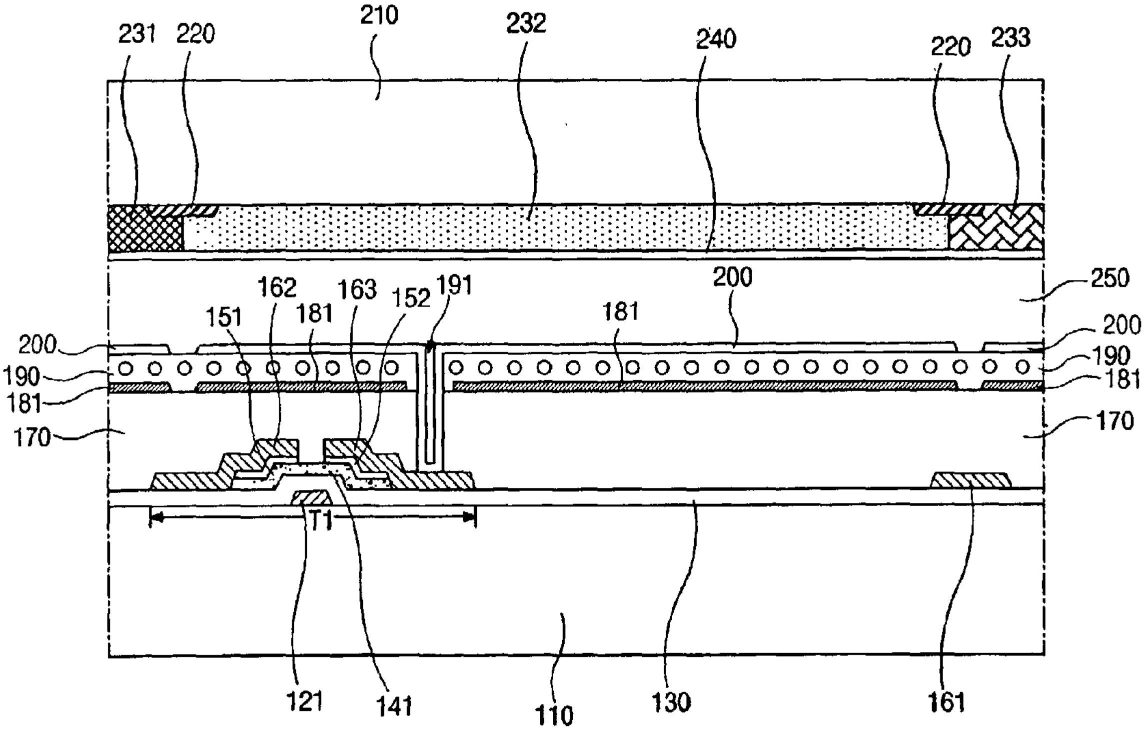


(related art)

FIG. 2



(related art)
FIG. 3


231
220
210
232
240
220
233
250
200
162
163
152
191
151
181
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200
200
190
190
181
181
170
170
T1
121
141
110
130
161

FIG. 4

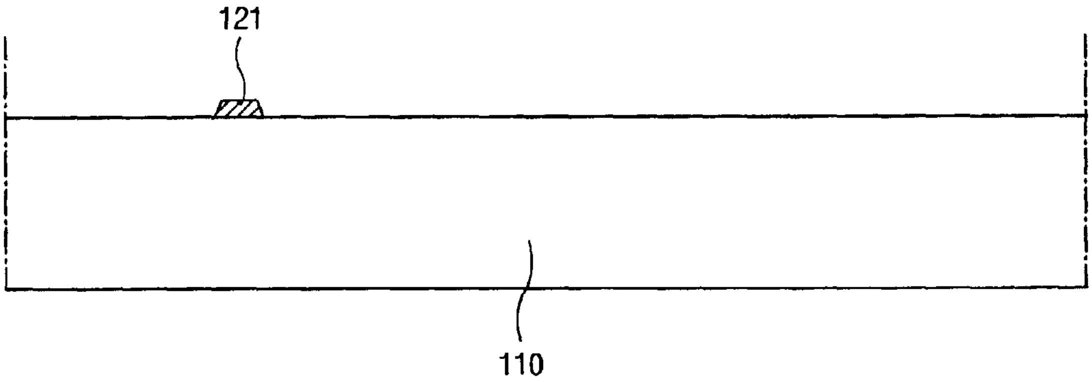

121
110

FIG. 5A

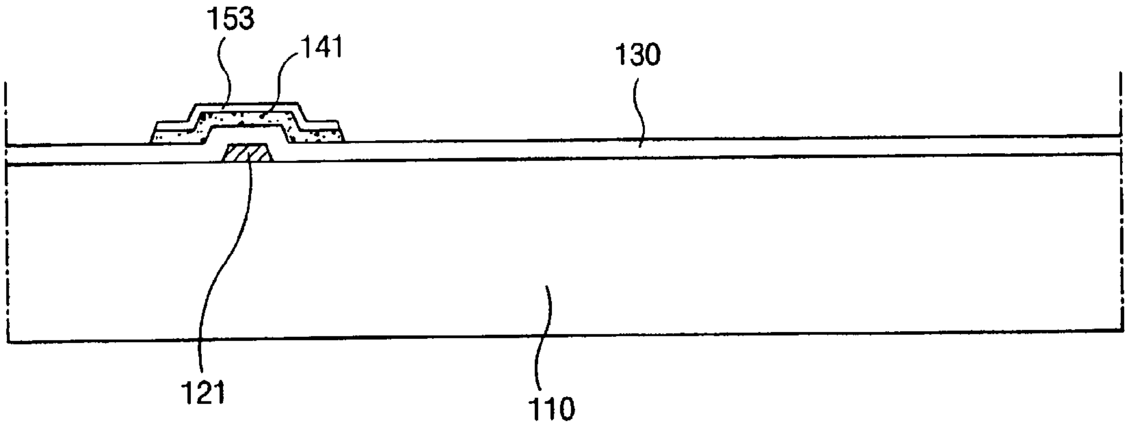


FIG. 5B

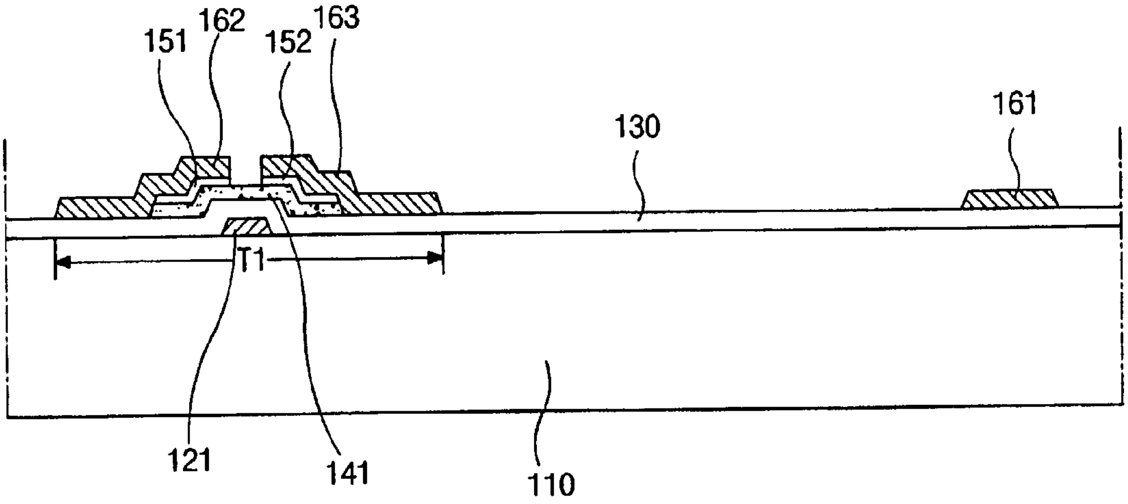


FIG. 5C

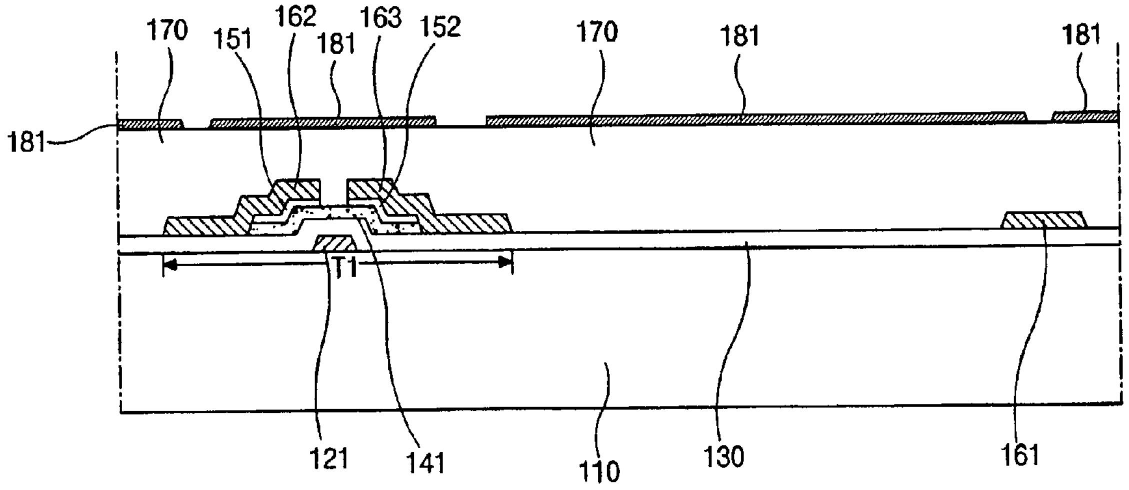
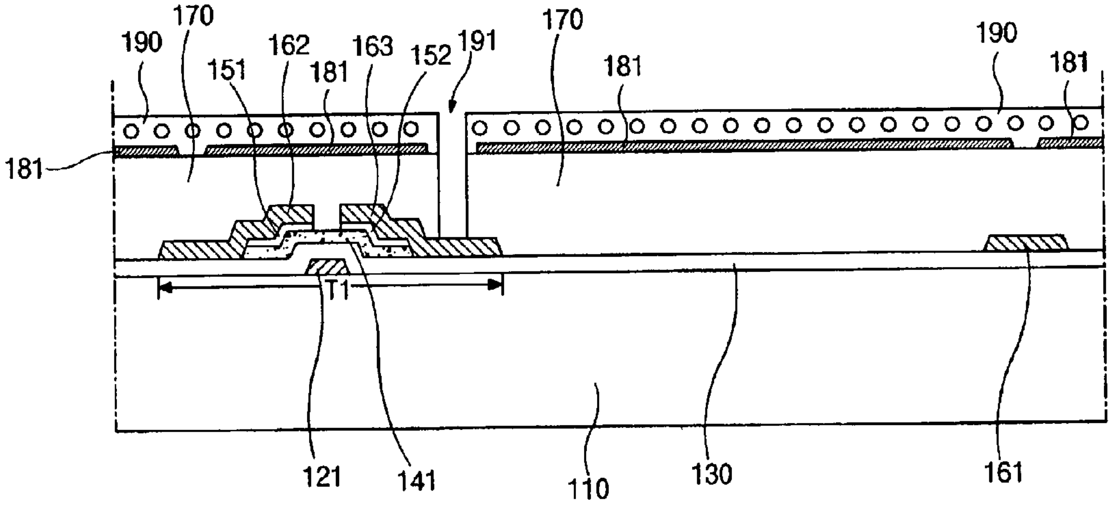

170
151
162
181
163
152
170
181
181
181
T1
121
141
110
130
161

FIG. 5D


190
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190
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181
T1
121
141
110
130
161

FIG. 5E

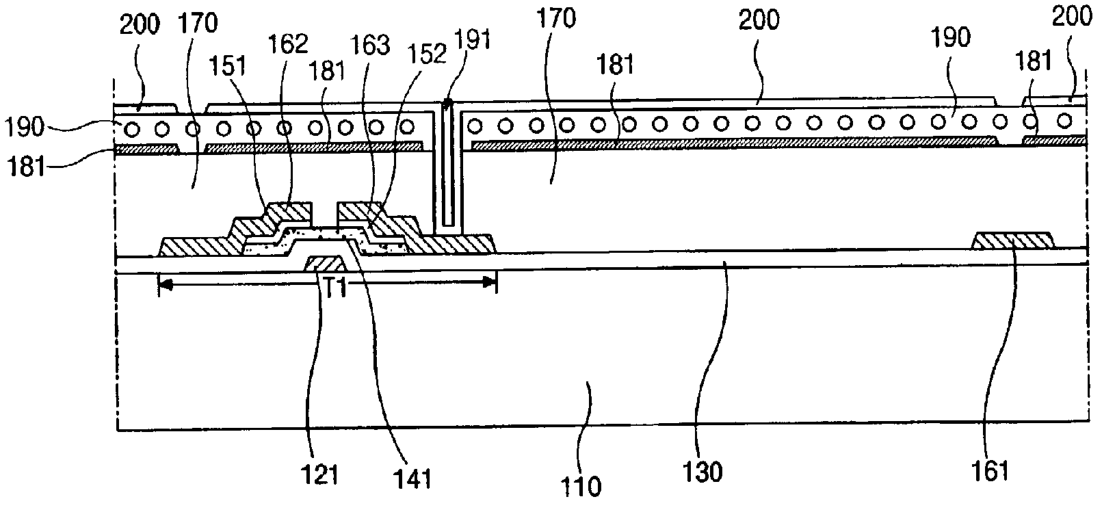


FIG. 5F

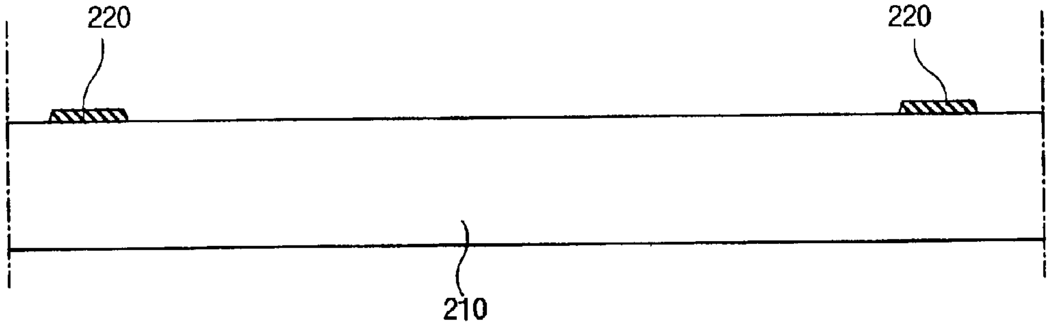


FIG. 6A

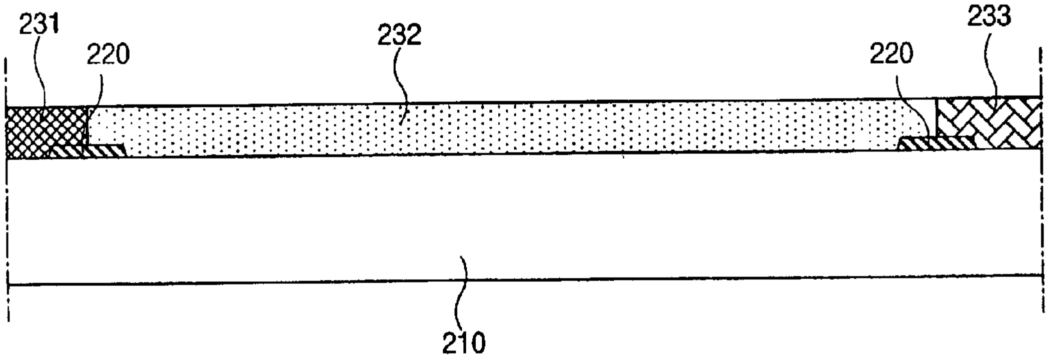
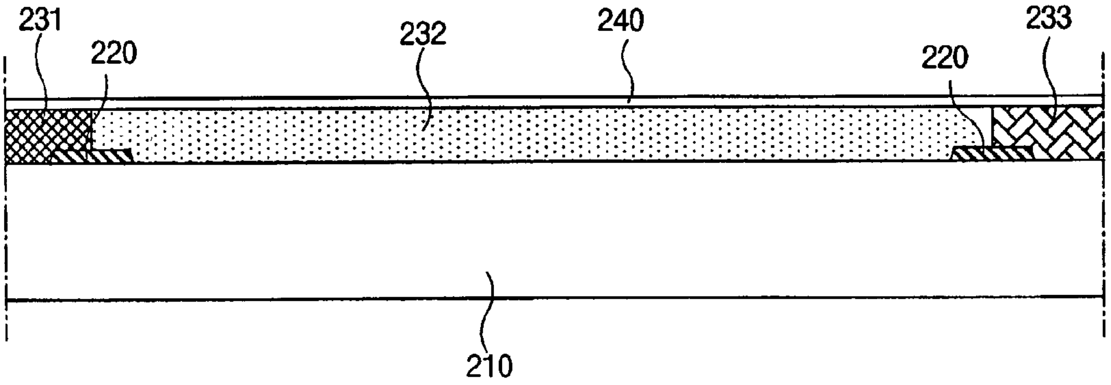


FIG. 6B


231
220
232
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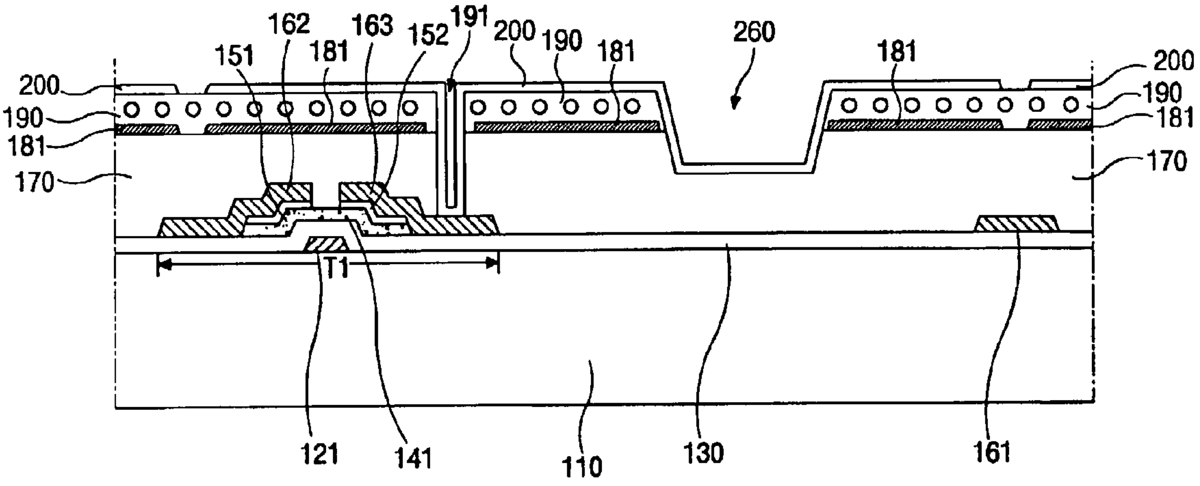
233
220
210

FIG. 6C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152
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181
181
170
170
T1
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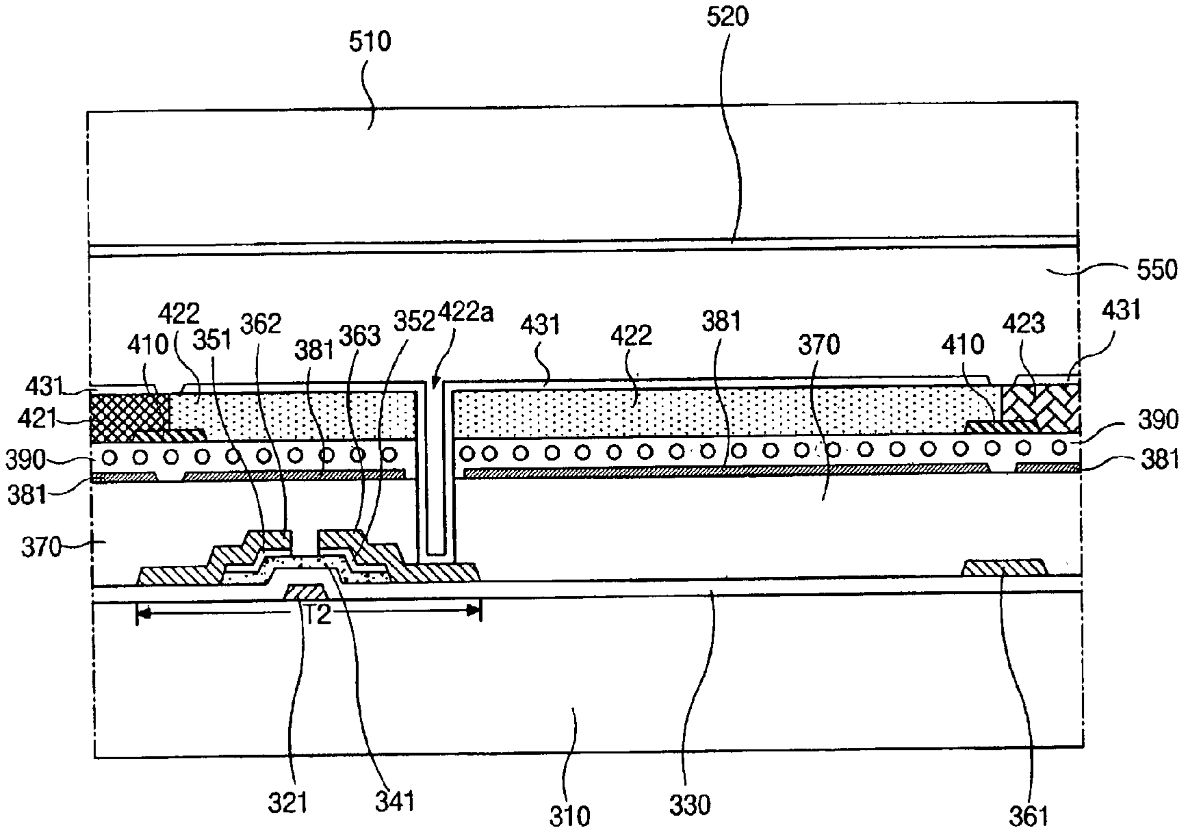
141
110
130
161

FIG. 7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550
431
422
410
351
362
381
363
352
422a
431
422
381
370
410
423
431
421
390
381
370
390
381
T2
321
341
310
330
361

FIG. 8

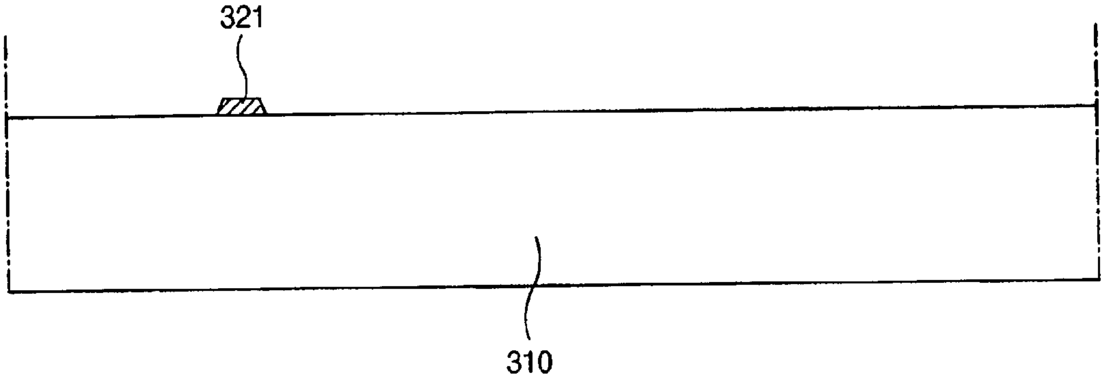

321
310

FIG. 9A

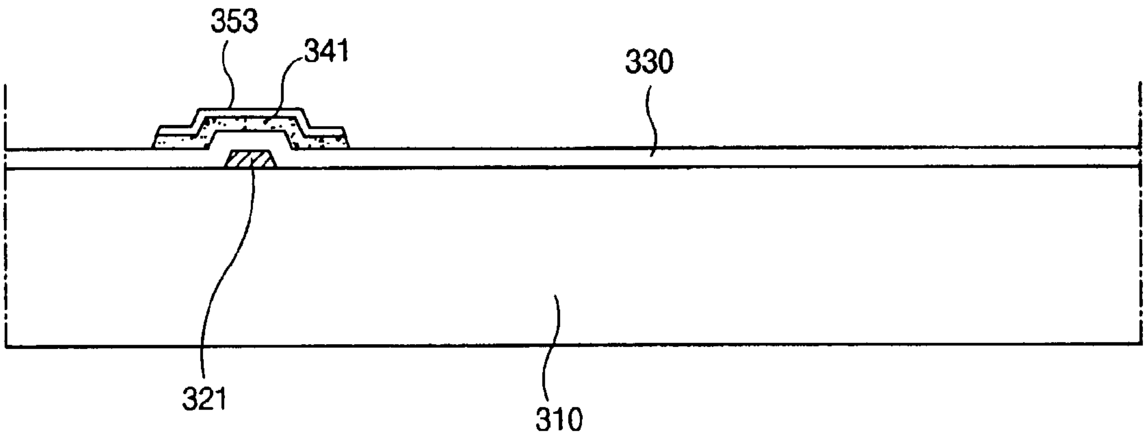


FIG. 9B

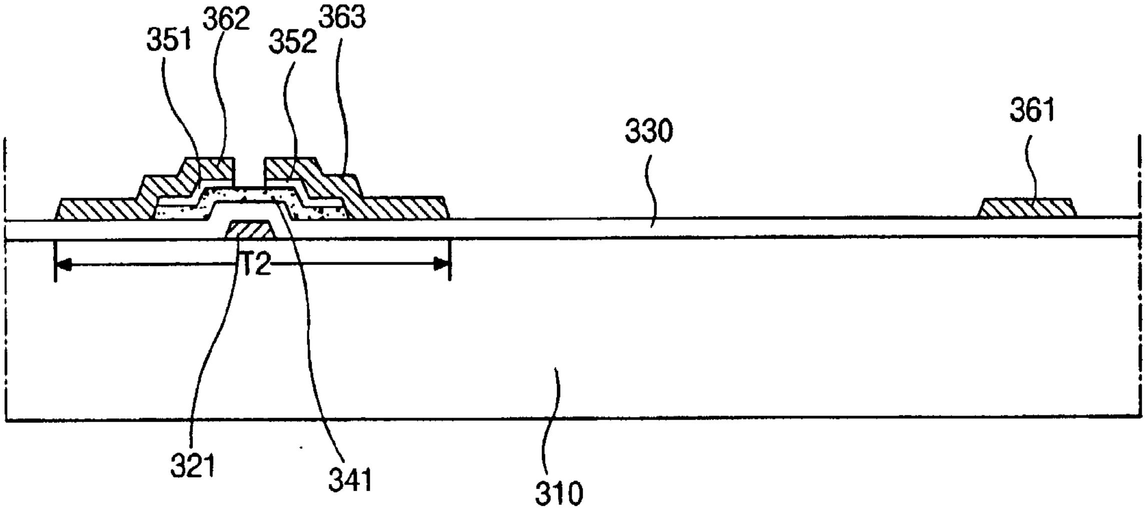
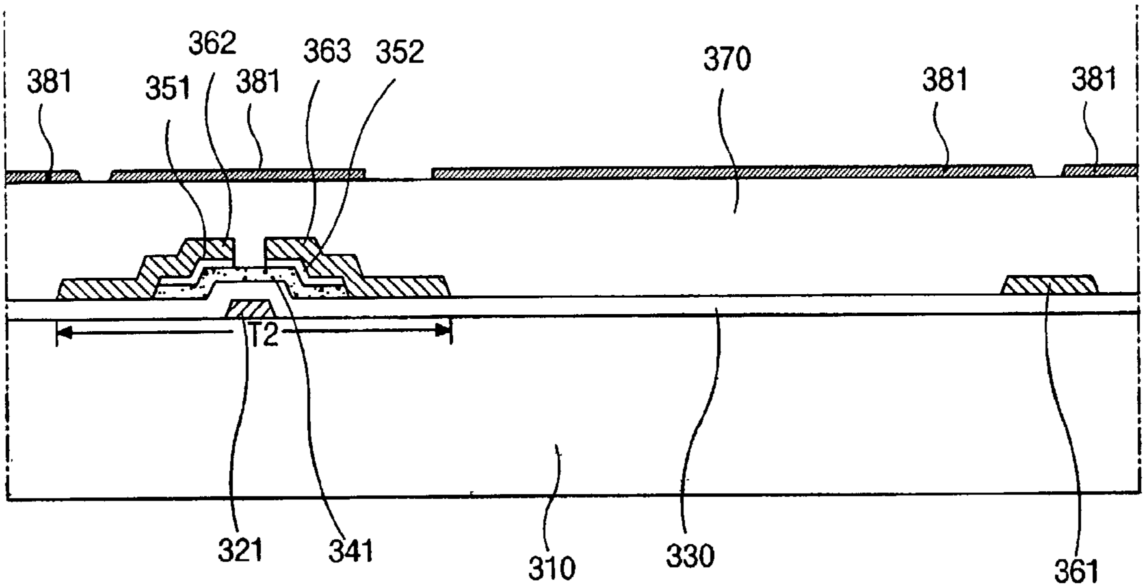


FIG. 9C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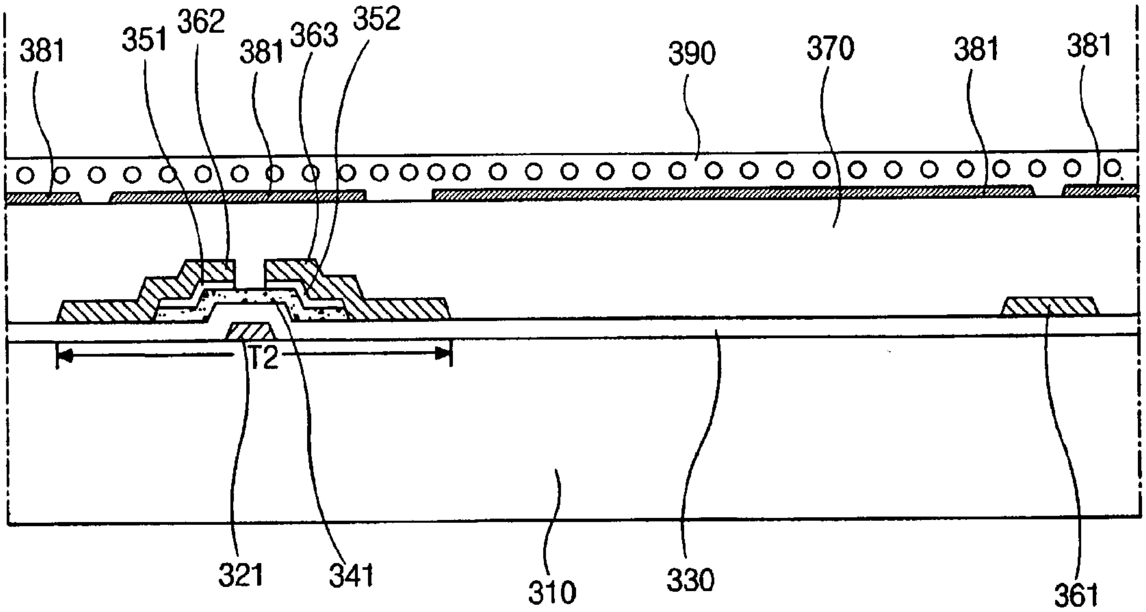
363
352
381
351
381
370
381
381
T2
321
341
310
330
361

FIG. 9D


381
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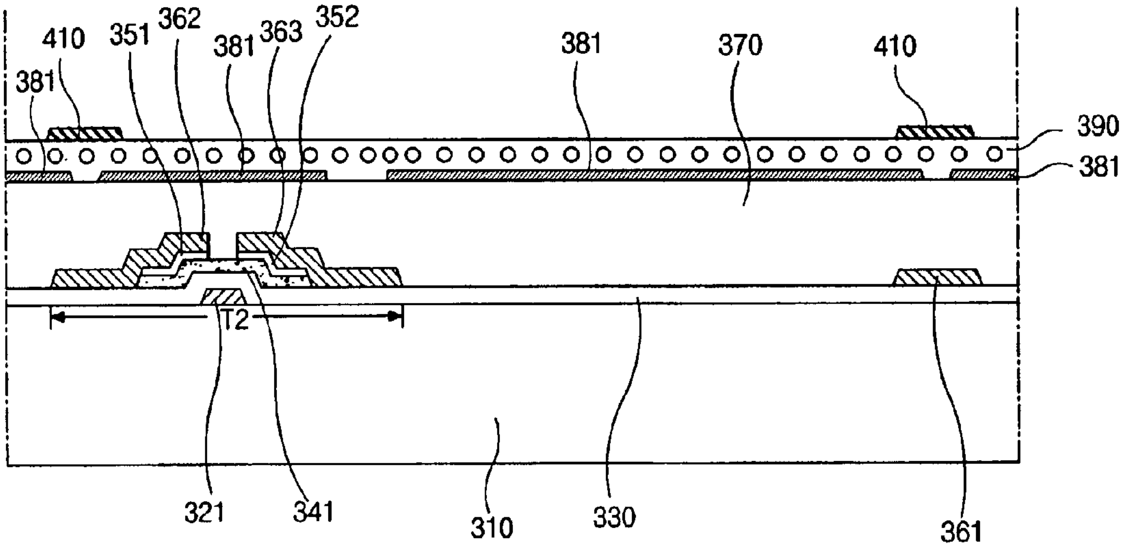
352
390
370
381
381
T2
321
341
310
330
361

FIG. 9E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T2
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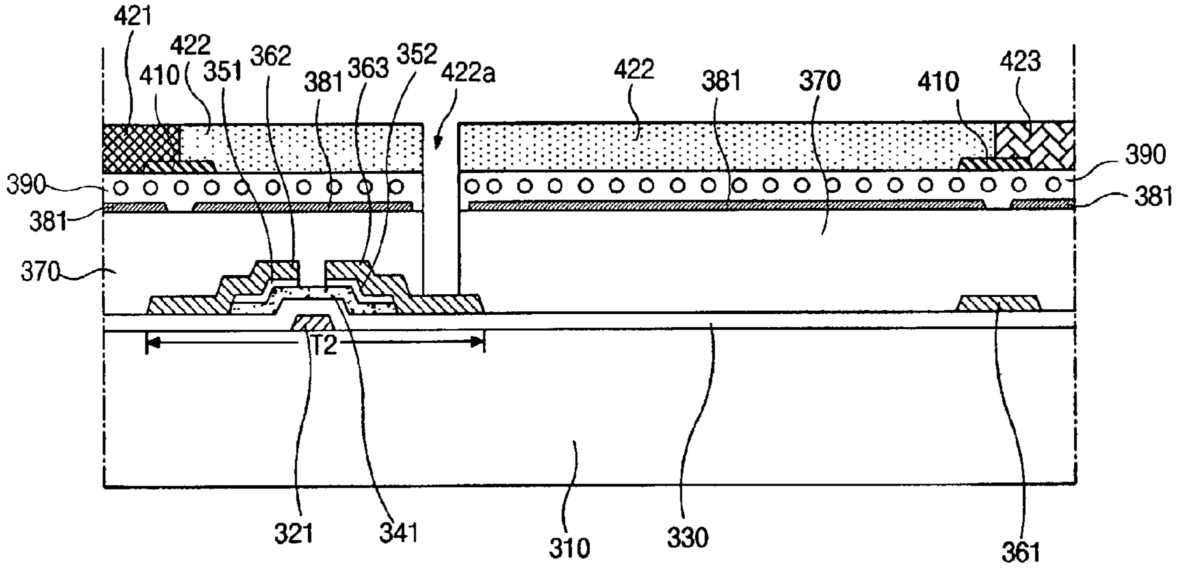
361

FIG. 9F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422a
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T2
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341
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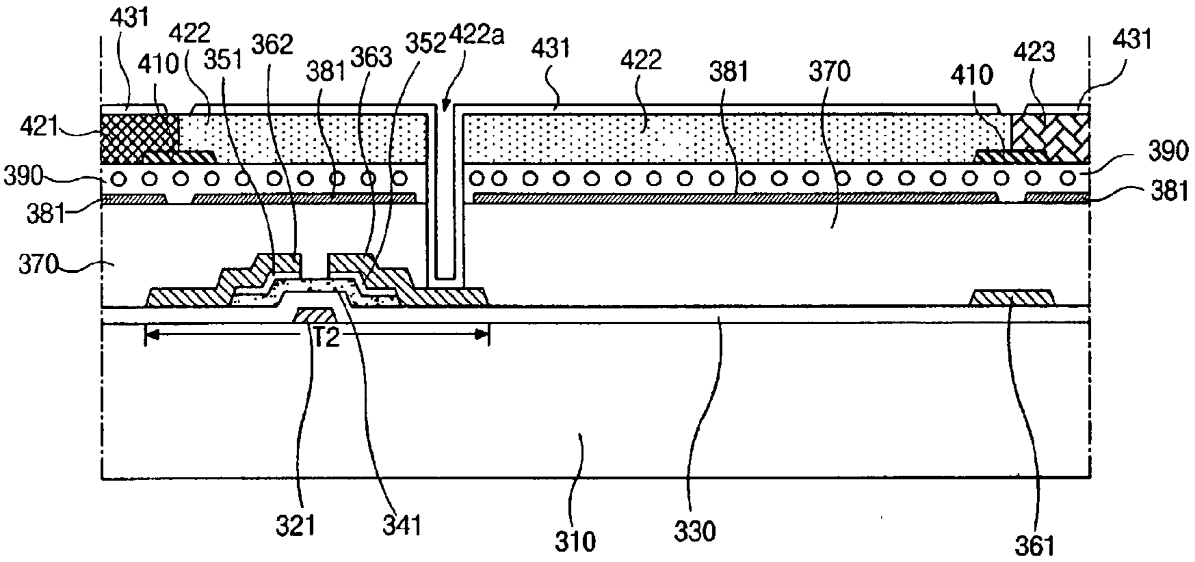
330
361

FIG. 9G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422a
431
422
381
370
410
423
431
421
390
381
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390
381
T2
321
341
310
330
361

FIG. 9H

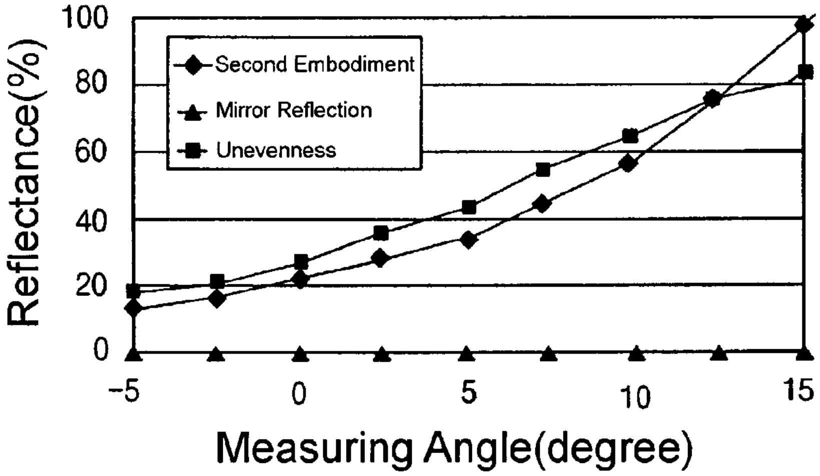
Reflectance(%)
100
80
60
40
20
0
-5
0
5
10
15
Measuring Angle(degree)
Second Embodiment
Mirror Reflection
Unevenness

FIG. 10

LIQUID CRYSTAL DISPLAY DEVICE WITH SCATTERING LAYER AND FABRICATING METHOD THEREOF

[0001] This application claims the benefit of Korean Patent Application No. 2001-87595, filed on Dec. 28, 2001, which is hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a liquid crystal display (LCD) device, and more particularly to a LCD device having a scattering layer and a fabricating method thereof.

[0004] 2. Discussion of the Related Art

[0005] Flat panel display (FPD) devices having a small size, lightweight, and low power consumption have been a subject of recent research in the advent of the information age. FPD devices may be classified into two types depending on whether the device emits or receives light. One type is a light-emitting type display device that emits light to display images, and the other type is a light-receiving type display device that uses an external light source to display images. Plasma display panels (PDPs), field emission display (FED) devices, and electroluminescent (EL) devices are examples of the light-emitting type display devices. Liquid crystal display (LCD) devices are examples of the light-receiving type display device. Among many kinds of FPD devices, LCD devices are widely used for notebook computers and desktop monitors because of their excellent characteristics of resolution, color display and display quality.

[0006] Generally, LCD devices include an upper substrate and a lower substrate facing each other with liquid crystal molecules interposed therebetween. Each substrate has an electrode on the inner surface thereof. An electric field is generated by applying a voltage to the electrodes, thereby driving the liquid crystal molecules to display images in accordance with the light transmittance.

[0007] Since LCD devices do not emit light, an additional light source is necessary. Accordingly, LCD devices display images by disposing a backlight at a backside thereof and transmitting light from the backlight. Here, electric field-generating electrodes of LCD devices are usually made of a transparent conductive material and the two substrates are usually transparent. This kind of LCD device is referred to as a transmission type LCD device or a transmissive LCD device. Even though a transmissive LCD device can display bright images under a dark environment due to an artificial light source such as a backlight, the transmissive LCD device has a disadvantage of high power consumption due to the backlight.

[0008] To remedy this disadvantage, a reflective (or reflection type) LCD device is suggested. The reflective LCD device displays images by reflecting external natural or artificial light, thereby having a low power consumption compared with the transmissive LCD device. In the reflective LCD device, a lower electric field-generating electrode is made of a conductive material having high reflectance and an upper electric field-generating electrode is made of a transparent conductive material so that external light can be transmitted through the upper electric field-generating electrode.

[0009] **FIG. 1** is a schematic cross-sectional view of a related art reflective LCD device. In **FIG. 1**, first and second substrates **11** and **21** are spaced apart from each other. A gate electrode **12** and a gate line (not shown) are formed on an inner surface of the first substrate **11** and a gate insulating layer **13** is formed on the gate electrode **12**. An active layer **14**, an ohmic contact layer **15***a* and **15***b,* and source and drain electrodes **16***b* and **16***c* are sequentially formed on the gate insulating layer **13** over the gate electrode **12** and constitutes a thin film transistor (TFT) "T" with the gate electrode **12**. A data line **16***a* of the same material as the source and drain electrodes **16***b* and **16***c* is also formed on the gate insulating layer **13** and connected to the source electrode **16***b.* The data line **16***a* crosses the gate line (not shown), thereby defining a pixel region. Next, a passivation layer **17** of an organic material is formed on the data line **16***a,* and the source and drain electrodes **16***b* and **16***c.* The passivation layer **17** covers the TFT "T" and has a contact hole **17***a* exposing the drain electrode **16***c.* A pixel electrode **18** is formed on the passivation layer **17** at the pixel region and connected to the drain electrode **16***c* through the contact hole **17***a.* Here, the pixel electrode **18** of a conductive material such as metal covers the TFT "T" and overlaps the data line **16***a* to improve an aperture ratio. Further, the passivation layer **17** is made of an organic material having a low dielectric constant to prevent signal interference between the pixel electrode **18** and the data line **16***a.*

[0010] A black matrix **22** is formed on an inner surface of the second substrate **21**. A color filter layer **23***a,* **23***b* and **23***c* having red, green and blue colors are formed on the black matrix **22**. A common electrode **24** of a transparent conductive material is formed on the color filter layer **23***a,* **23***b* and **23***c.* Here, one color of the color filter layer **23***a,* **23***b* and **23***c* corresponds the pixel electrode **18** and the black matrix covers an edge of the pixel electrode **18**. Since the pixel electrode **18** of an opaque material covers the TFT "T", the black matrix **22** can overlap only the edge of the pixel electrode **18**.

[0011] A liquid crystal layer **30** is interposed between the pixel electrode **18** and the common electrode **24**. Further, orientation films (not shown) that determine an initial alignment state of liquid crystal molecules are formed on the pixel electrode **18** and the common electrode **24**, respectively.

[0012] As mentioned above, the reflective LCD device displays images by reflecting an incident light at the pixel electrode of a high reflective material. Therefore, the reflective LCD device can operate for a longer time without exchanging a battery because power consumption is reduced.

[0013] Since the related art reflective electrode has a flat surface, light is reflected as if the reflective electrode is a mirror. This phenomenon is referred to as a mirror reflection. Therefore, the brightness is higher only along any reflection direction depending on Snell's Law of Refraction. When incident light is reflected on a reflective display according to a position of a light source, the brightness is low along a normal direction of an LCD device. Another phenomenon that occurs is the light glare effect. This happens when a high-intensity external light source is reflected on a liquid crystal display panel. The displayed image is poor due to the glare that occurs as viewed by an observer due to the reflection of light. To increase the brightness along the normal direction and decrease the light glare effect on an LCD device, a reflective electrode of an uneven shape and a front scattering film are suggested.

[0014] **FIG. 2** is a schematic cross-sectional view of a related art reflective LCD device using a front scattering film. In **FIG. 2, a** front scattering film **40** is disposed on an outer surface of a second substrate **21**. However, an image blurring phenomenon due to back scattering at the front scattering film **40** degrades a display efficiency of the reflective LCD device.

[0015] **FIG. 3** is a schematic cross-sectional view of a related art reflective LCD device using a reflective plate of an uneven shape. In **FIG. 3, a** surface of a pixel electrode **18** that is a reflective plate has an uneven shape by forming a passivation layer **17** that has an uneven surface. Accordingly, a brightness along a normal direction of the reflective LCD device increases by changing a reflection angle of light.

[0016] A slanting angle of the uneven shape may be about 10° so that light can be reflected along the normal direction of the reflective LCD device. However, a process of forming the uneven shape is a complicated process and has a low repeatability. The uneven shape of the passivation layer is initially formed to have a square shape. Subsequently, the passivation layer is cured to form a round shape. Uniform curing of the entire area of the passivation layer is difficult because it is dependent on the curing conditions. The curing temperature may range from about 100° C. to about 200° C. As a result, the uneven shape is not uniform throughout the entire area of the passivation layer. It is difficult to increase a brightness of a reflective LCD device even using a reflective electrode of an uneven shape due to a smaller effective scattering area of the light on the surface of the substrate. Moreover, since the pixel electrode is made of a metallic material and the common electrode is made of a transparent conductive material, a flicker occurs due to a work function difference between the pixel electrode and the common electrode.

SUMMARY OF THE INVENTION

[0017] Accordingly, the present invention is directed to a liquid crystal display device that substantially obviates one or more of problems due to limitations and disadvantages of the related art.

[0018] An advantage of the present invention is to provide a liquid crystal display device having a high brightness along a main viewing angle and a minimized flicker, and a fabricating method thereof.

[0019] Another advantage of the present invention is to provide a liquid crystal display device where brightness along a main viewing angle is high and a misalignment of the upper and lower substrates is prevented, and a fabricating method thereof.

[0020] Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0021] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, a liquid crystal display device includes: first and second substrates facing and spaced apart from each other; a gate line and a data line on an inner surface of the first substrate, the gate line and the data line crossing each other and defining a pixel region; a thin film transistor connected to the gate line and the data line, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes; a passivation layer covering the gate line, the data line and the thin film transistor; a reflective plate of an opaque material on the passivation layer at the pixel region; a scattering layer on the reflective plate, the scattering layer having a contact hole exposing the drain electrode through the passivation layer; a pixel electrode of a transparent conductive material on the scattering layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole.

[0022] The liquid crystal display device further includes a black matrix on an inner surface of the second substrate, the black matrix covering an edge of the pixel electrode; a color filter layer on the black matrix, the color filter layer having red, green and blue colors; a common electrode on the color filter layer; and a liquid crystal layer interposed between the pixel electrode and the common electrode.

[0023] In another aspect of the present invention, a liquid crystal display device includes: first and second substrates facing and spaced apart from each other; a gate line and a data line on an inner surface of the first substrate, the gate line and the data line crossing each other and defining a pixel region; a thin film transistor connected to the gate line and the data line, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes; a passivation layer covering the gate line, the data line and the thin film transistor; a reflective plate of an opaque material on the passivation layer at the pixel region; a scattering layer on the reflective plate; a color filter layer on the scattering layer, the color filter layer having red, green and blue colors, the color filter layer having a contact hole exposing the drain electrode through the passivation layer and the scattering layer; a pixel electrode of a transparent conductive material on the color filter layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole.

[0024] The liquid crystal display device further includes a black matrix on the scattering layer, the black matrix overlapping the reflective plate; a common electrode on an inner surface of a second substrate; and a liquid crystal layer interposed between the pixel electrode and the common electrode.

[0025] In another aspect of the present invention, a fabricating method of a liquid crystal display device includes: forming a gate line and a data line on a first substrate, the gate line and the data line crossing each other and defining a pixel region; forming a thin film transistor connected to the gate line and the data line, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes; forming a passivation layer covering the gate line, the data line and the thin film transistor; forming a reflective plate of an opaque material on the passivation layer at the pixel region; forming a scattering layer on the reflective plate, the scattering layer having a contact hole exposing the drain electrode through the passivation layer; forming a pixel electrode of a transparent conductive material on the scattering layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole.

[0026] The fabricating method further includes forming a black matrix on a second substrate, the black matrix covering an edge of the pixel electrode; forming a color filter layer on the black matrix, the color filter layer having red, green and blue colors; forming a common electrode on the color filter layer; attaching the first and second substrates, the pixel electrode and the common electrode facing to each other; and injecting a liquid crystal material into a space between the pixel electrode and the common electrode.

[0027] In another aspect of the present invention, a fabricating method of a liquid crystal display device includes: forming a gate line and a data line on a first substrate, the gate line and the data line crossing each other and defining a pixel region; forming a thin film transistor connected to the gate line and the data line, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes; forming a passivation layer covering the gate line, the data line and the thin film transistor; forming a reflective plate of an opaque material on the passivation layer at the pixel region; forming a scattering layer on the reflective plate; forming a color filter layer on the scattering layer, the color filter layer having red, green and blue colors, the color filter layer having a contact hole exposing the drain electrode through the passivation layer and the scattering layer; forming a pixel electrode of a transparent conductive material on the color filter layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole; forming a common electrode on a second substrate; attaching the first and second substrates, the pixel electrode and the common electrode facing to each other; and injecting a liquid crystal material into a space between the pixel electrode and the common electrode.

[0028] In another aspect of the present invention, a liquid crystal display device, comprises: first and second substrates facing and spaced apart from each other; a gate line and a data line on an inner surface of the first substrate, the gate line and the data line crossing each other and defining a pixel region; a thin film transistor connected to the gate line and the data line, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes; a passivation layer covering the gate line, the data line and the thin film transistor; a reflective plate of an opaque material on the passivation layer at the pixel region, the reflective plate having a transmissive portion; a scattering layer on the reflective plate, the scattering layer having a contact hole exposing the drain electrode through the passivation layer; and a pixel electrode of a transparent conductive material on the scattering layer and the passivation layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole.

[0029] The liquid crystal display device further comprises a transmissive portion which includes a hole wherein a portion of the pixel electrode is formed in the hole below the reflective plate. The transmissive portion is formed by etching a portion of the passivation layer and the scattering layer corresponding to the transmissive portion.

[0030] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention.

[0032] In the drawings:

[0033] **FIG. 1** is a schematic cross-sectional view of a related art reflective LCD device;

[0034] **FIG. 2** is a schematic cross-sectional view of a related art reflective LCD device using a front scattering film;

[0035] **FIG. 3** is a schematic cross-sectional view of a related art reflective LCD device using a reflective plate of an uneven shape;

[0036] **FIG. 4** is a schematic cross-sectional view of a reflective LCD device according to a first embodiment of the present invention;

[0037] **FIGS. 5A** to **5**F are schematic cross-sectional views showing a fabricating process of a first substrate for a reflective LCD device according to the first embodiment of the present invention;

[0038] **FIGS. 6A** to **6**C are schematic cross-sectional views showing a fabricating method of a second substrate for a reflective LCD device according to the first embodiment of the present invention;

[0039] **FIG. 7** is a schematic cross-sectional view of an array substrate for a transflective LCD device according to a second embodiment of the present invention;

[0040] **FIG. 8** is a schematic cross-sectional view of a reflective LCD device according to a third embodiment of the present invention;

[0041] **FIGS. 9A** to **9**H are schematic cross-sectional views showing a fabricating process of a first substrate for a reflective LCD device according to the third embodiment of the present invention; and

[0042] **FIG. 10** is a graph showing a reflectance of reflective LCD devices using a reflective plate of a mirror reflection, a reflective plate of an uneven shape, and a scattering layer (the third embodiment).

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0043] Reference will now be made in detail to embodiments of the present invention, example of which are illustrated in the accompanying drawings. Wherever possible, similar reference numbers will be used throughout the drawings to refer to the same or like parts.

[0044] **FIG. 4** is a schematic cross-sectional view of a reflective LCD device according to a first embodiment of the present invention.

[0045] In **FIG. 4**, first and second substrates **110** and **210** are spaced apart from each other. A gate electrode **121** is formed on an inner surface of the first substrate **110** and a gate insulating layer **130** of silicon nitride (SiNx) or silicon oxide (SiO_2) is formed on the gate electrode **121**. A gate line (not shown) connected to the gate electrode **121** is also formed on the inner surface of the first substrate **110**. Next, an active layer **141** of amorphous silicon is formed on the gate insulating layer **130** over the gate electrode **121** and an ohmic contact layer **151** and **152** of impurity-doped amorphous silicon is formed on the active layer **141**. A data line **161**, and source and drain electrodes **162** and **163** of a conductive material such as metal are formed on the ohmic contact layer **151** and **152**. The data line **161** connected to the source electrode **162** crosses the gate line to define a pixel region (not shown). The gate electrode **121**, the active layer **141**, and the source and drain electrodes **162** and **163** constitute a thin film transistor (TFT) "T1." Next, a passivation layer **170** is formed on the data line **161**, and the source and drain electrodes **162** and **163**. The passivation layer **170** includes an organic material having a low dielectric constant. Next, a reflective plate **181** of an opaque material such as metal is formed on the passivation layer **170**. The reflective plate **181** covers the TFT "T1" and overlaps the data line **161** so that an aperture ratio can be improved. Next, a scattering layer **190** is formed on the reflective plate **181**. The scattering layer **190** of polymer has a contact hole **191** exposing the drain electrode **163** through the passivation layer **170**. Next, a pixel electrode **200** of a transparent conductive material is formed on the scattering layer **190**. The pixel electrode **200** is connected to the drain electrode **163** through the contact hole **191** and separated from the reflective plate **181**.

[0046] Next, a black matrix **220** is formed on an inner surface of the second substrate **210**. The black matrix **220** covering an edge of the pixel electrode **200** prevents light leakage at the outside of the pixel region. Generally, the black matrix **220** covers the TFT "T1" to prevent a photocurrent generation of the TFT "T1." Since the reflective plate **181** of an opaque material covers the TFT "T1" and prevents light from entering a channel of the TFT "T1" in the present invention, the black matrix **220** may not be formed over the TFT "T1." Next, a color filter layer **231**, **232** and **233** having red, green and blue colors is formed on the black matrix **220**. One color of the color filter layer **231**, **232** and **233** corresponds to one pixel region. Next, a common electrode **240** of a transparent conductive material is formed on the color filter layer **231**, **232** and **233**. The common electrode **240** has substantially the same material as the pixel electrode **200**. The common electrode **240** and the pixel electrode **200** may have one of indium-tin-oxide (ITO) and indium-zinc-oxide (IZO). The black matrix **220** can be omitted.

[0047] Next, a liquid crystal layer **250** is interposed between the pixel electrode **200** and the common electrode **240**. Liquid crystal molecules of the liquid crystal layer **250** are aligned according to an electric field generated between the pixel electrode **200** and the common electrode **240** when a voltage is applied to the pixel electrode **200** and the common electrode **240**. Orientation films (not shown) determining an initial alignment state of the liquid crystal molecules are formed on the pixel electrode **200** and the common electrode **240**, respectively.

[0048] In the present invention, since the scattering layer **190** on the reflective plate **181** scatters reflected light, brightness along a normal direction of the reflective LCD device increases. Moreover, since the pixel electrode **200** on the scattering layer **190** has the same material as the common electrode **240**, there is no work function difference between the pixel electrode **200** and the common electrode **240**. As a result, a flicker is prevented and image blurring is minimized.

[0049] **FIGS. 5A** to **5**F are schematic cross-sectional views showing a fabricating process of a first substrate for a reflective LCD device according to the first embodiment of the present invention.

[0050] In **FIG. 5A, a** gate electrode **121** is formed on a first substrate **110** through depositing and patterning a conductive material such as metal. Here, a gate line (not shown) connected to the gate electrode **121** is simultaneously formed on the first substrate **110**. The gate electrode **121** and the gate line is made of a material having a low resistivity to prevent a signal delay.

[0051] In **FIG. 5B, a** gate insulating layer **130** is formed on the gate electrode **121** through depositing one of silicon nitride (SiNx) and silicon oxide (SiO_2). An active layer **141** and an impurity-doped semiconductor layer **153** are sequentially formed on the gate insulating layer **130** over the gate electrode **121** through depositing and patterning amorphous silicon and impurity-doped amorphous silicon.

[0052] In **FIG. 5C, a** data line **161**, and source and drain electrodes **162** and **163** are formed through depositing and patterning a conductive material such as metal. Subsequently, an ohmic contact layer **151** and **152** is completed through etching the impurity-doped semiconductor layer **153** (of **FIG. 5B**) exposed between the source and drain electrodes **162** and **163**. Here, the data line **161** is connected to the source electrode **162** and defines a pixel region (not shown) by crossing the gate line (not shown). The source and drain electrodes **162** and **163** constitute a thin film transistor (TFT) "T1" with the gate electrode **121**.

[0053] In **FIG. 5**D, after a passivation layer **170** is formed through depositing an organic material, a reflective plate **181** is formed at the pixel region through depositing and patterning an opaque material such as metal. Here, the passivation layer **170** is made of an organic material having a low dielectric constant, for example, benzocyclobutene (BCB) or acrylic resin. The reflective plate **181** overlaps the data line **161** and covers the TFT "T1." Further, the reflective plate **181** may be made of a material having a high reflectance such as aluminum (Al), aluminum-neodymium (AlNd), silver (Ag) or gold (Au). Here, a portion of the reflective plate **181** over the drain electrode **163** is also eliminated.

[0054] In **FIG. 5E, a** scattering layer **190** is formed on the reflective plate **181**. The scattering layer **190** has a contact hole **191** exposing the drain electrode **163** through the passivation layer **170** by a method such as etching. The scattering layer **190** may be formed through spin-coating a polymer matrix where a spherical particle is dispersed and hardening the coated polymer matrix, or through coating a polymer matrix, dispersing a spherical particle into the coated polymer matrix by a spray, and hardening the coated polymer matrix where the spherical particle is dispersed.

Here, the polymer matrix may have one of polyamide, polyimide and photoacrylic resin. As the number of spherical particles included in the polymer matrix increases, a scattering degree increases and the thickness of the scattering layer **190** increases. Therefore, it is preferable that a diameter of the spherical particle is within a range of about 1 to about 20 μm considering a thickness of the scattering layer **190** and a wavelength of incident light. Here, the scattering layer **190** may include the spherical particles of diverse sizes or one size. Even though the contact hole **191** is made through simultaneously patterning the scattering layer **190** and the passivation layer **170** in the present invention, the contact hole **191** may be completed through patterning the passivation layer **170** to make a first contact hole before forming the scattering layer **190** and patterning the scattering layer **190** to make a second contact hole corresponding to the first contact hole.

[0055] In **FIG. 5F, a** pixel electrode **200** is formed on the scattering layer **190** through depositing and patterning a transparent conductive material such as indium-tin-oxide (ITO) or indium-zinc-oxide (IZO). The pixel electrode **200** is connected to the drain electrode **163** through the contact hole **191** and separated from the reflective plate **181**. The pixel electrode **200** may overlap the data line **161** and cover the TFT “T1.”

[0056] **FIGS. 6A** to **6C** are schematic cross-sectional views showing a fabricating method of a second substrate for a reflective LCD device according to the first embodiment of the present invention.

[0057] In **FIG. 6A, a** black matrix **220** is formed on a second substrate **210** through depositing and patterning one of metal such as chromium (Cr) and black resin.

[0058] In **FIG. 6B, a** color filter layer **231**, **232** and **233** having red, green and blue color is formed on the black matrix **220**. One of a pigment dispersion method, a dyeing method and a printing method may be used for a formation of the color filter layer **231**, **232** and **233**.

[0059] In **FIG. 6C, a** common electrode **240** is formed on the color filter layer **231, 232** and **233** through depositing a transparent conductive material such as ITO or IZO. Here, an overcoat layer (not shown) of an organic material may be formed between the color filter layer **231, 232** and **233** and the common electrode **240**.

[0060] A reflective LCD device shown in **FIG. 4** is completed through attaching the first and second substrates **110** (of **FIG. 5E**) and **210** (of **FIG. 6C**) in such a way that the pixel electrode **200** (of **FIG. 5E**) and the common electrode **240** (of **FIG. 6C**) face to each other and injecting a liquid crystal material into a space between the pixel electrode **200** (of **FIG. 5E**) and the common electrode **240** (of **FIG. 6C**).

[0061] The reflective LCD device according to the first embodiment may have a disadvantage such as light leakage due to a misalignment during an attaching process. To prevent the disadvantage, a black matrix of an upper substrate may be formed to have a larger width. In this case, however, an aperture ratio decreases. Accordingly, a method of forming a black matrix and a color filter layer on a lower substrate is suggested to prevent the misalignment and increase the aperture ratio.

[0062] A transflective liquid crystal display device using a scattering layer is possible as shown in **FIG. 7**.

[0063] **FIG. 7** is a schematic cross-sectional view of an array substrate for a transflective LCD device according to a second embodiment of the present invention.

[0064] In **FIG. 7**, the reflective plate **181** and scattering layer **190** have a transmissive hole **260** formed therethrough. The scattering layer **190** is formed only on the reflective plate **181**. A pixel electrode **200** of transparent conductive material is formed on the scattering layer **190** in a reflective part and on the passivation layer **170** in a transmissive part through the transmissive hole **260**. The passivation layer **170** may be etched to a level below the reflective plate **181** to form the transmissive hole **260**.

[0065] **FIG. 8** is a schematic cross-sectional view of a reflective LCD device according to a third embodiment of the present invention. In **FIG. 8**, first and second substrates **310** and **510** are spaced apart from each other. A gate electrode **321** is formed on an inner surface of the first substrate **310** and a gate insulating layer **330** of silicon nitride (SiNx) or silicon oxide (SiO_2) is formed on the gate electrode **321**. A gate line (not shown) connected to the gate electrode **321** is also formed on the inner surface of the first substrate **310**. Next, an active layer **341** of amorphous silicon is formed on the gate insulating layer **330** over the gate electrode **321** and an ohmic contact layer **351** and **352** of impurity-doped amorphous silicon is formed on the active layer **341**. A data line **361**, and source and drain electrodes **362** and **363** of a conductive material such as metal are formed on the ohmic contact layer **351** and **352**. The data line **361** connected to the source electrode **362** crosses the gate line to define a pixel region (not shown). The gate electrode **321**, the active layer **341**, and the source and drain electrodes **362** and **363** constitute a thin film transistor (TFT) “T2.” Next, a passivation layer **370** is formed on the data line **361**, and the source and drain electrodes **362** and **363**. Preferably, the passivation layer **370** includes an organic material having a low dielectric constant. Next, a reflective plate **381** of an opaque material such as metal is formed on the passivation layer **370**. The reflective plate **381** covers the TFT “T2” and overlaps the data line **361** so that an aperture ratio can be improved. Next, a scattering layer **390** of polymer including a spherical particle is formed on the reflective plate **381** and a black matrix **400** is formed on the scattering layer **390**. Next, a color filter layer **421, 422** and **423** having red, green and blue colors alternately is formed on the black matrix **400**. One color of the color filter layer **421, 422** and **423** corresponds to one pixel region. The color filter layer **421**, **422** and **423** has a contact hole **422***a* exposing the drain electrode **363** in common withthrough the passivation layer **370** and the scattering layer **390**. Next, a pixel electrode **431** of a transparent conductive material is formed on the color filter layer **421, 422** and **423**. The pixel electrode **431** is connected to the drain electrode **363** through the contact hole **422***a* and separated from the reflective plate **381**.

[0066] A common electrode **520** of a transparent conductive material such as indium-tin-oxide (ITO) or indium-zinc-oxide (IZO) is formed on an inner surface of the second substrate **510**.

[0067] A liquid crystal layer **550** is interposed between the pixel electrode **431** and the common electrode **520**. Orientation films (not shown) are formed on the pixel electrode **431** and the common electrode **520**, respectively.

[0068] **FIGS. 9A** to **9H** are schematic cross-sectional views showing a fabricating process of a first substrate for a reflective LCD device according to the third embodiment of the present invention.

[0069] In **FIG. 9A, a** gate electrode **321** is formed on an inner surface of the first substrate **310** through depositing and patterning a conductive material such as metal. The gate electrode **321** is made of a material having a low resistivity to prevent a signal delay.

[0070] In **FIG. 9B, a** gate insulating layer **330** of silicon nitride (SiNx) or silicon oxide (SiO_2) is formed on the gate electrode **321**. A gate line (not shown) connected to the gate electrode **321** is also formed on the inner surface of the first substrate **310**. Next, an active layer **341** of amorphous silicon and an impurity-doped semiconductor layer **353** are sequentially formed on the gate insulating layer **330** over the gate electrode **321** through depositing and patterning amorphous silicon and impurity-doped amorphous silicon.

[0071] In **FIG. 9C, a** data line **361**, and source and drain electrodes **362** and **363** of a conductive material such as metal are formed through depositing and patterning a conductive material such as metal. Subsequently, an ohmic contact layer **351** and **352** is completed through etching the impurity-doped semiconductor layer **353** (of **FIG. 9B**) exposed between the source and drain electrodes **362** and **363**. Here, the data line **361** is connected to the source electrode **362** and crosses the gate line (not shown) to define a pixel region (not shown). The gate electrode **321**, the active layer **341**, and the source and drain electrodes **362** and **363** constitute a thin film transistor (TFT) "T2."

[0072] In **FIG. 9D, a** passivation layer **370** is formed on the data line **361** through depositing an organic material having a low dielectric constant. Next, a reflective plate **381** of an opaque material such as metal is formed on the passivation layer **370**. The reflective plate **381** covers the TFT "T2" and overlaps the data line **361** so that an aperture ratio can be improved. Further, the reflective plate **381** may be made of a material having a high reflectance such as aluminum (Al), aluminum-neodymium (AlNd), silver (Ag) or gold (Au). Here, a portion of the reflective plate **381** over the drain electrode **363** is also removed.

[0073] In **FIG. 9E, a** scattering layer **390** of polymer including a spherical particle is formed on the reflective plate **381**. The scattering layer **390** may be formed through spin-coating a polymer matrix where a spherical particle is dispersed and hardening the coated polymer matrix, or through coating a polymer matrix, dispersing a spherical particle into the coated polymer matrix by a spray, and hardening the coated polymer matrix where the spherical particle is dispersed. Here, the polymer matrix may have one of polyamide, polyimide and photoacrylic resin. As the number of spherical particles included in the polymer matrix increases, a scattering degree increases and the thickness of the scattering layer **390** increases. As illustrated in the first embodiment, it is preferable that a diameter of the spherical particle is within a range of about 1 to about 20 μm considering a thickness of the scattering layer **390** and a wavelength of incident light. Here, the scattering layer **390** may include the spherical particles of diverse sizes or one size.

[0074] In **FIG. 9F, a** black matrix **410** is formed on the scattering layer **390** through depositing and patterning a metal such as chromium (Cr) or using black resin.

[0075] In **FIG. 9C**; a color filter layer **421**, **422** and **423** having red, green and blue colors is formed on the black matrix **410**. One color of the color filter layer **421**, **422** and **423** corresponds to one pixel region. The color filter layer **421**, **422** and **423** has a contact hole **422*a*** exposing the drain electrode **363** through the passivation layer **370** and the scattering layer **390**.

[0076] In **FIG. 9H, a** pixel electrode **431** of a transparent conductive material is formed on the color filter layer **421**, **422** and **423** through depositing and patterning a transparent conductive material such as indium-tin-oxide (ITO) or indium-zinc-oxide (IZO). The pixel electrode **431** is connected to the drain electrode **363** through the contact hole **422*a*** and separated from the reflective plate **381**. The pixel electrode **431** may overlap the data line **361** and cover the TFT "T2."

[0077] After a common electrode **520** of a transparent conductive material such as indium-tin-oxide (ITO) or indium-zinc-oxide (IZO) is formed on an inner surface of the second substrate **510** (of **FIG. 8**), the first and second substrates **310** and **510** are spaced apart from each other and are attached in such a way that the pixel electrode **431** (of **FIG. 9H**) and the common electrode **520** (of **FIG. 8**) face to each other.

[0078] The reflective LCD device shown in **FIG. 8** is completed through injecting a liquid crystal material **550** into a space between the pixel electrode **431** (of **FIG. 9H**) and the common electrode **520**. Orientation films (not shown) are formed on the pixel electrode **431** and the common electrode **520**, respectively.

[0079] **FIG. 10** is a graph showing a reflectance of reflective LCD devices using a reflective plate of a mirror reflection, a reflective plate of an uneven shape, and a scattering layer (the second embodiment). The reflectance is normalized with respect to a reflectance using magnesium oxide (MgO) to measure the efficiency of the light intensity and incident light enters the reflective LCD device with an angle of 30° with respect to a normal direction of the reflective LCD device. The reflectance is measured at a viewing angle of −5 to 15°.

[0080] As shown in **FIG. 9**, for a reflective plate of a mirror reflection, since the incident light is reflected only with a reflected angle of 30°, reflected light is nearly not measured at the viewing angle of −5 to 15°. For the second embodiment, i.e., a color filter layer and a scattering layer on a reflective plate, reflected light increases in proportion to the rise in the viewing angle and the reflectance is similar to that of a reflective plate of an uneven shape.

[0081] Consequently, since a scattering layer is formed on a reflective plate and a pixel electrode of the same material as a common electrode is formed thereon, brightness increases at a range of main viewing angle and a flicker is prevented. Moreover, since a color filter layer is formed on the scattering layer, a misalignment of the upper and lower substrates is prevented without a reduction of reflectance.

[0082] It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A liquid crystal display device, comprising:

first and second substrates facing and spaced apart from each other;

a gate line and a data line on an inner surface of the first substrate, the gate line and the data line crossing each other and defining a pixel region;

a thin film transistor connected to the gate line and the data line, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes;

a passivation layer covering the gate line, the data line and the thin film transistor;

a reflective plate of an opaque material on the passivation layer at the pixel region;

a scattering layer on the reflective plate, the scattering layer having a contact hole exposing the drain electrode through the passivation layer; and

a pixel electrode of a transparent conductive material on the scattering layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole.

2. The device according to claim 1, further comprising:

a color filter layer on an inner surface of the second substrate, the color filter layer having red, green and blue colors; and

a common electrode on the color filter layer.

3. The device according to claim 2, further comprising:

a black matrix on the inner surface of the second substrate, the black matrix covering an edge of the pixel electrode.

4. The device according to claim 2, wherein the pixel electrode and the common electrode include one of indium-tin-oxide and indium-zinc-oxide.

5. The device according to claim 1, wherein the scattering layer includes one of polyamide, polyimide and photoacrylic resin.

6. The device according to claim 5, wherein the scattering layer includes a spherical particle.

7. The device according to claim 6, wherein a diameter of the spherical particle is within a range of about 1 μm to about 20 μm.

8. The device according to claim 1, wherein the passivation layer includes an organic insulating material.

9. The device according to claim 8, wherein the organic insulating material is one of benzocyclobutene and acrylic resin.

10. The device according to claim 1, wherein the pixel electrode overlaps the data line.

11. The device according to claim 2, further comprising a liquid crystal layer interposed between the pixel electrode and the common electrode.

12. A liquid crystal display device, comprising:

first and second substrates facing and spaced apart from each other;

a gate line and a data line on an inner surface of the first substrate, the gate line and the data line crossing each other and defining a pixel region;

a thin film transistor connected to the gate line and the data line, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes;

a passivation layer covering the gate line, the data line and the thin film transistor;

a reflective plate of an opaque material on the passivation layer at the pixel region;

a scattering layer on the reflective plate;

a color filter layer on the scattering layer, the color filter layer having red, green and blue colors, the color filter layer having a contact hole exposing the drain electrode through the passivation layer and the scattering layer;

a pixel electrode of a transparent conductive material on the color filter layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole;

a common electrode on an inner surface of the second substrate; and

a liquid crystal layer interposed between the pixel electrode and the common electrode.

13. The device according to claim 12, further comprising:

a black matrix on the scattering layer, the black matrix overlapping the reflective plate.

14. The device according to claim 12, wherein the pixel electrode and the common electrode include one of indium-tin-oxide and indium-zinc-oxide.

15. The device according to claim 12, wherein the scattering layer includes one of polyamide, polyimide and photoacrylic resin.

16. The device according to claim 15, wherein the scattering layer includes a spherical particle.

17. The device according to claim 16, wherein a diameter of the spherical particle is within a range of about 1 μm to about 20 μm.

18. The device according to claim 12, wherein the passivation layer includes an organic insulating material.

19. The device according to claim 18, wherein the organic insulating material includes one of benzocyclobutene and acrylic resin.

20. The device according to claim 12, wherein the pixel electrode overlaps the data line.

21. A fabricating method of a liquid crystal display device, comprising:

forming a gate line and a data line on a first substrate, the gate line and the data line crossing each other and defining a pixel region;

forming a thin film transistor connected to the gate line and the data line, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes;

forming a passivation layer covering the gate line, the data line and the thin film transistor;

forming a reflective plate of an opaque material on the passivation layer at the pixel region;

forming a scattering layer on the reflective plate, the scattering layer having a contact hole exposing the drain electrode through the passivation layer;

forming a pixel electrode of a transparent conductive material on the scattering layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole.

22. The method according to claim 21, further comprising:

forming a color filter layer on a second substrate, the color filter layer having red, green and blue colors;

forming a common electrode on the color filter layer.

23. The method according to claim 22, further comprising:

forming a black matrix on the inner surface of the second substrate, the black matrix covering an edge of the pixel electrode.

24. The method according to claim 22, further comprising:

attaching the first and second substrates, the pixel electrode and the common electrode facing to each other; and

injecting a liquid crystal material into a space between the pixel electrode and the common electrode.

25. The method according to claim 21, wherein the scattering layer includes a spherical particle.

26. The method according to claim 25, wherein forming the scattering layer comprises:

coating the polymer matrix including the spherical particle; and

hardening the coated polymer matrix.

27. The method according to claim 25, wherein forming the scattering layer comprises:

coating the polymer matrix;

dispersing the spherical particle into the coated polymer matrix; and

hardening the polymer matrix where the spherical particle is dispersed.

28. A fabricating method of a liquid crystal display device, comprising:

forming a gate line and a data line on a first substrate, the gate line and the data line crossing each other and defining a pixel region;

forming a thin film transistor connected to the gate line and the data line, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes;

forming a passivation layer covering the gate line, the data line and the thin film transistor;

forming a reflective plate of an opaque material on the passivation layer at the pixel region;

forming a scattering layer on the reflective plate;

forming a color filter layer on the scattering layer, the color filter layer having red, green and blue colors, the color filter layer having a contact hole exposing the drain electrode through the passivation layer and the scattering layer;

forming a pixel electrode of a transparent conductive material on the color filter layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole;

forming a common electrode on a second substrate;

attaching the first and second substrates, the pixel electrode and the common electrode facing each other; and

injecting a liquid crystal material into a space between the pixel electrode and the common electrode.

29. The method according to claim 28, further comprising:

a black matrix on the scattering layer, the black matrix overlapping the reflective plate.

30. The method according to claim 28, wherein the scattering layer includes a spherical particle.

31. The method according to claim 30, wherein the step of forming the scattering layer comprises:

coating the polymer matrix including the spherical particle; and

hardening the coated polymer matrix.

32. The method according to claim 30, wherein the step of forming the scattering layer comprises:

coating the polymer matrix;

dispersing the spherical particle into the coated polymer matrix; and

hardening the polymer matrix where the spherical particle is dispersed.

33. A liquid crystal display device, comprising:

first and second substrates facing and spaced apart from each other;

a gate line and a data line on an inner surface of the first substrate, the gate line and the data line crossing each other and defining a pixel region;

a thin film transistor connected to the gate line and the data line, the thin film transistor having a gate electrode, an active layer, and source and drain electrodes;

a passivation layer covering the gate line, the data line and the thin film transistor;

a reflective plate of an opaque material on the passivation layer at the pixel region, the reflective plate having a transmissive portion;

a scattering layer on the reflective plate, the scattering layer having a contact hole exposing the drain electrode through the passivation layer; and

a pixel electrode of a transparent conductive material on the scattering layer and the passivation layer at the pixel region, the pixel electrode being connected to the drain electrode through the contact hole.

34. The device of claim 33, wherein the transmissive portion includes a hole.

35. The device of claim 34, wherein a portion of the pixel electrode is formed in the hole below the reflective plate.

36. The device of claim 35, wherein the transmissive portion is formed by etching a portion of the passivation layer and the scattering layer corresponding to the transmissive portion.

* * * * *

专利名称(译)	具有散射层的液晶显示装置及其制造方法		
公开(公告)号	US20030122980A1	公开(公告)日	2003-07-03
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[标]申请(专利权)人(译)	劲炫SUK 姜元SEOK		
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摘要(译)

一种反射型液晶显示装置，包括彼此面对且间隔开的第一和第二基板。薄膜晶体管连接到限定像素区域的栅极线和数据线，薄膜晶体管具有栅电极，有源层以及源电极和漏电极。钝化层覆盖栅极线，数据线和薄膜晶体管。在像素区域处的钝化层上形成不透明材料的反射板。在反射板上形成散射层，散射层具有通过钝化层暴露漏电极的接触孔。透明导电材料的像素电极形成在像素区域的散射层上，像素电极通过接触孔连接到漏电极。黑矩阵形成在第二基板的内表面上，黑矩阵覆盖像素电极的边缘。在黑色矩阵上形成滤色器层，滤色器层具有红色，绿色和蓝色。在滤色器层上形成公共电极。液晶层介于像素电极和公共电极之间。