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(54) **COLOR LIQUID CRYSTAL DISPLAY AND METHOD OF MANUFACTURING COLOR LIQUID CRYSTAL DISPLAY**

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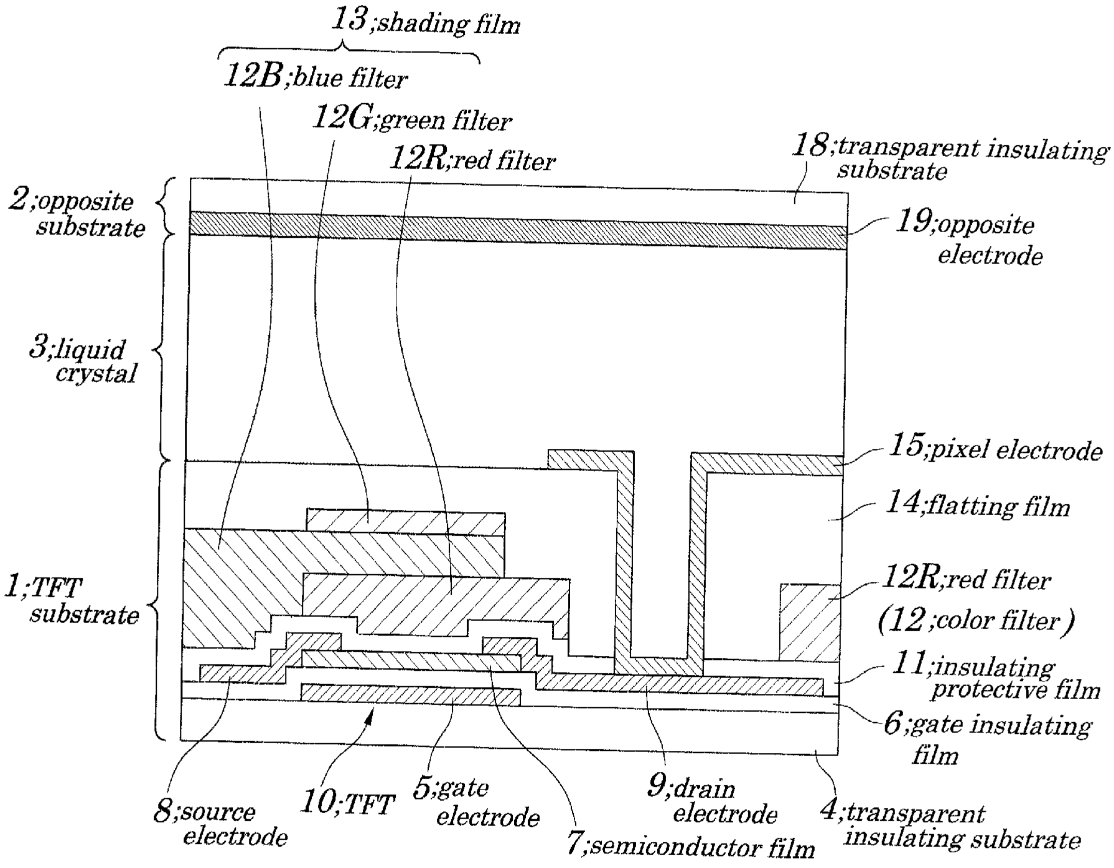
(57) **ABSTRACT**

In a color liquid crystal display, a shading film including a first filter formed from a red resist film, a second filter formed from a blue resist film laminated on the first filter and a third filter formed from a green resist film laminated on the first filter and the second filter is formed on a TFT substrate. Therefore, increment of an optical leak in the TFT is restricted when the shading film is formed by laminating plural filters to be a color filter.



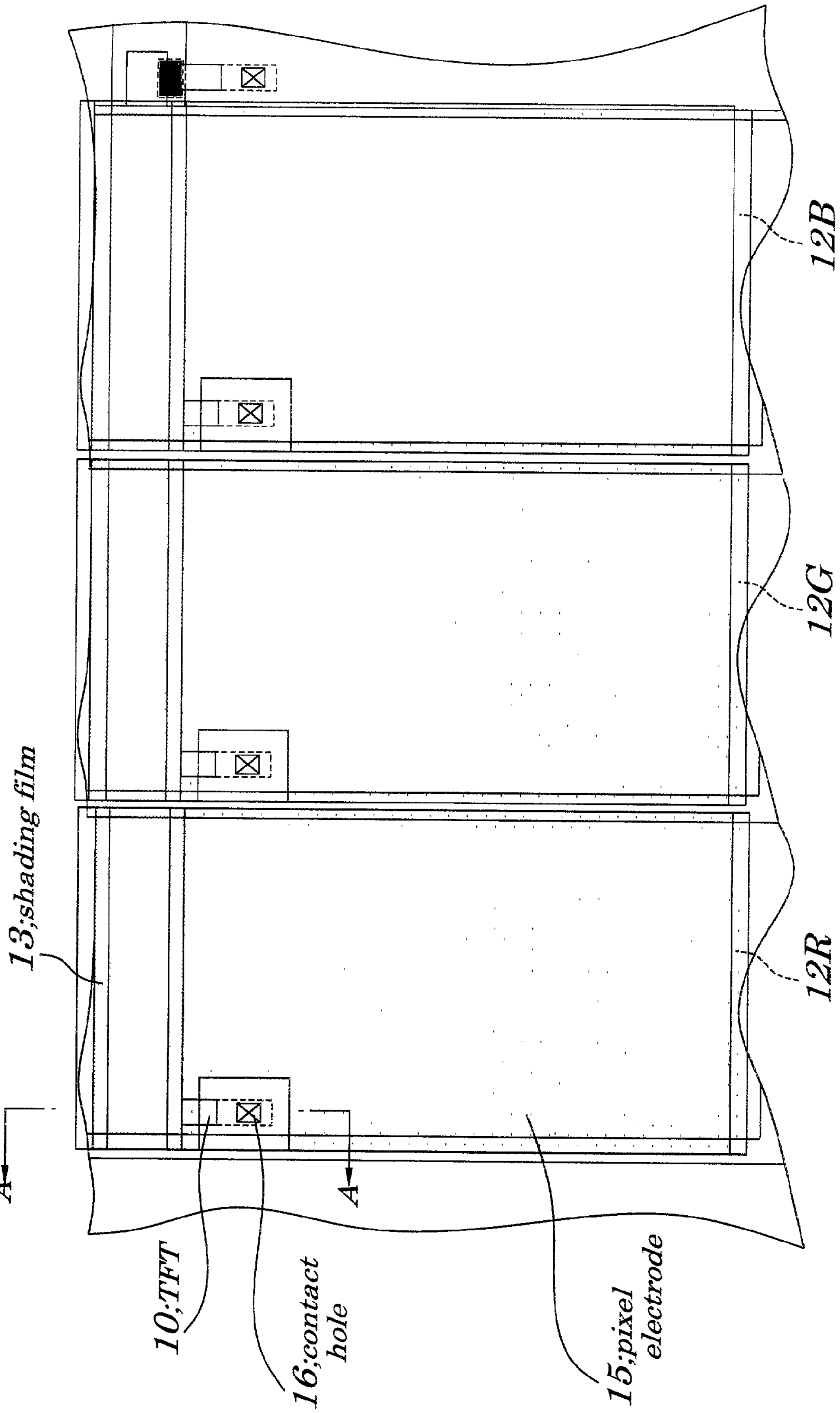
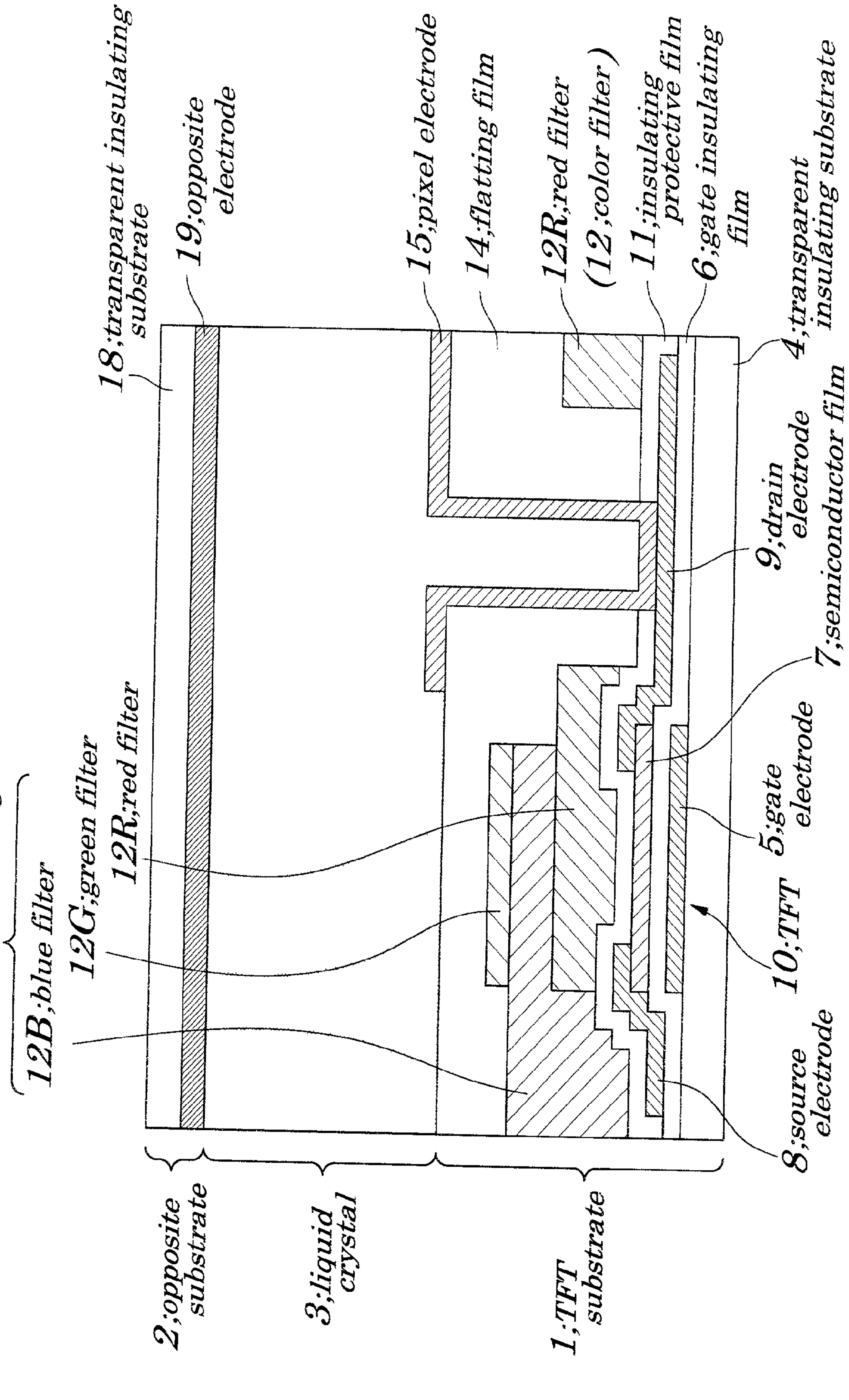

12B
12G
12R
13;shading film
A
A
10;TFT
16;contact hole
15;pixel electrode

FIG.1

FIG.2



18;transparent insulating substrate
19;opposite electrode
15;pixel electrode
14;flatting film
12R;red filter
(12;color filter)
11;insulating protective film
6;gate insulating film
4;transparent insulating substrate
13;shading film
12B;blue filter
12G;green filter
12R;red filter
9;drain electrode
7;semiconductor film
5;gate electrode
10;TFT
8;source electrode
2;opposite substrate
3;liquid crystal
1;TFT substrate

FIG.3A

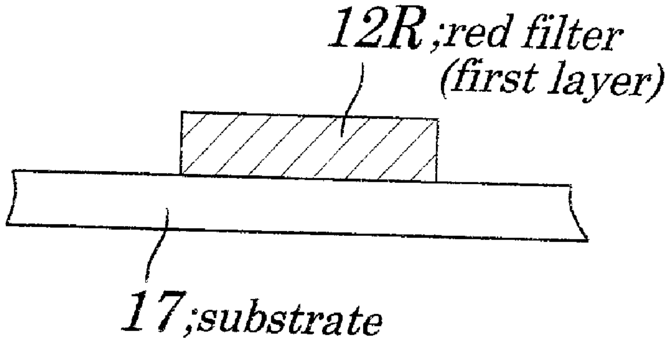


FIG.3B

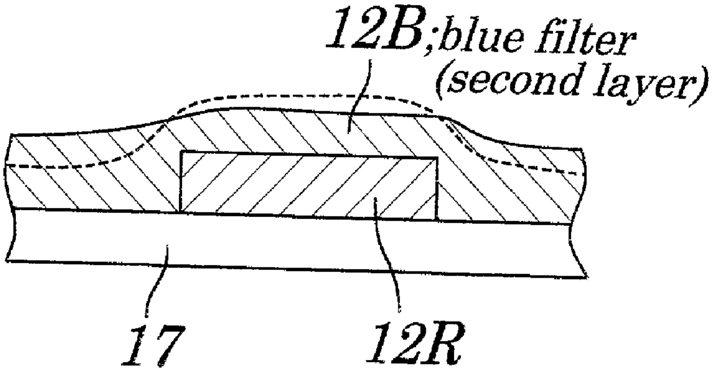


FIG.3C

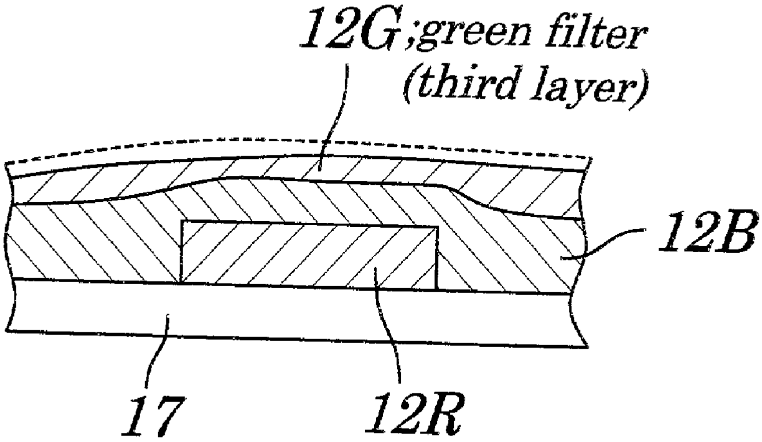


FIG. 4

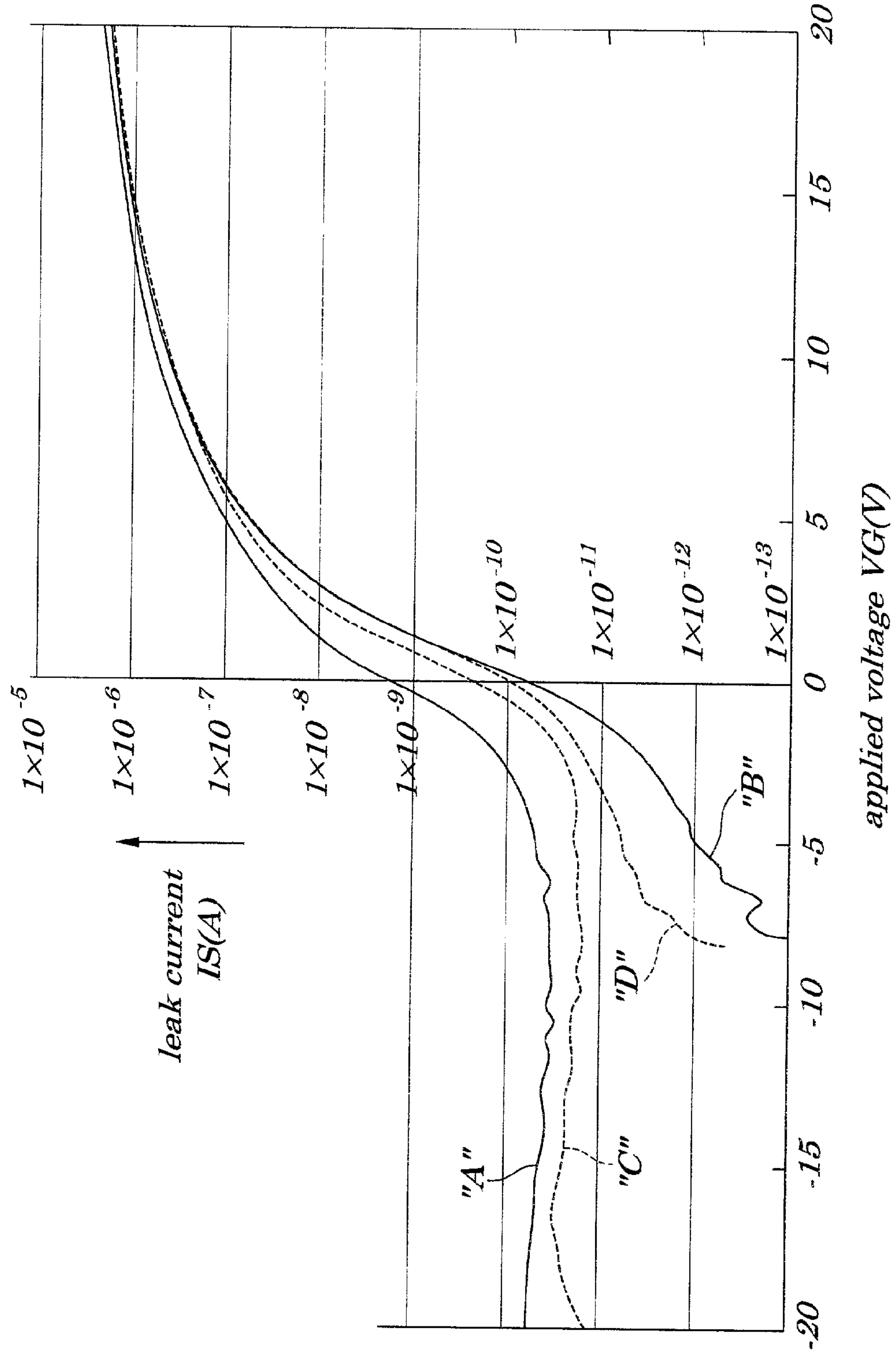

leak current IS(A)
applied voltage VG(V)
1×10^-5
1×10^-6
1×10^-7
1×10^-8
1×10^-9
1×10^-10
1×10^-11
1×10^-12
1×10^-13
-20
-15
-10
-5
0
5
10
15
20
"A"
"B"
"C"
"D"

FIG.5A

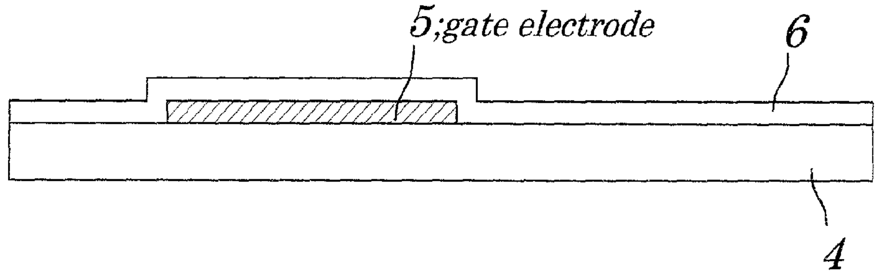


FIG.5B

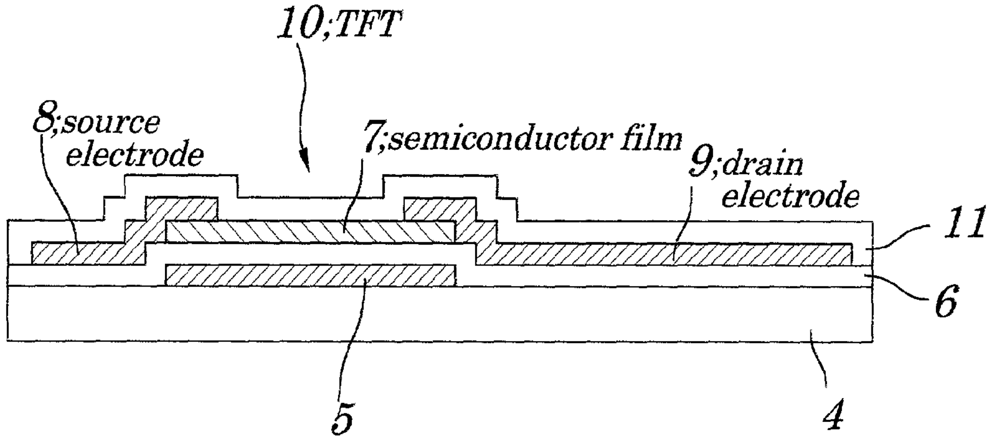


FIG.5C

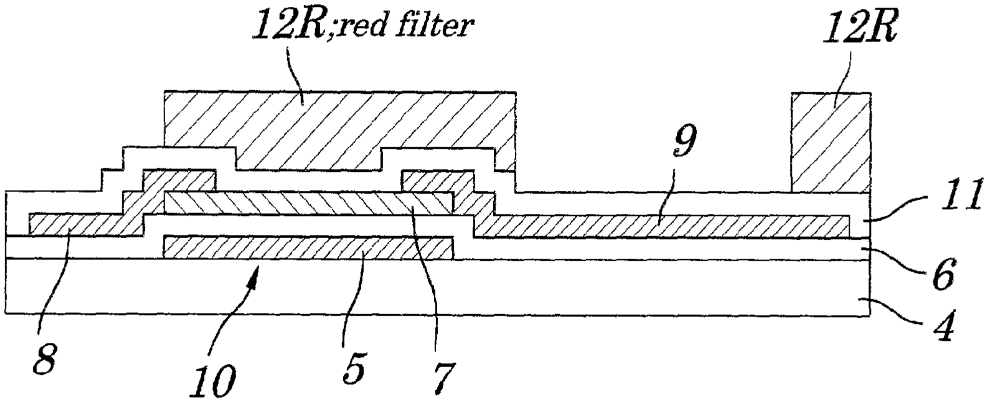


FIG.5D

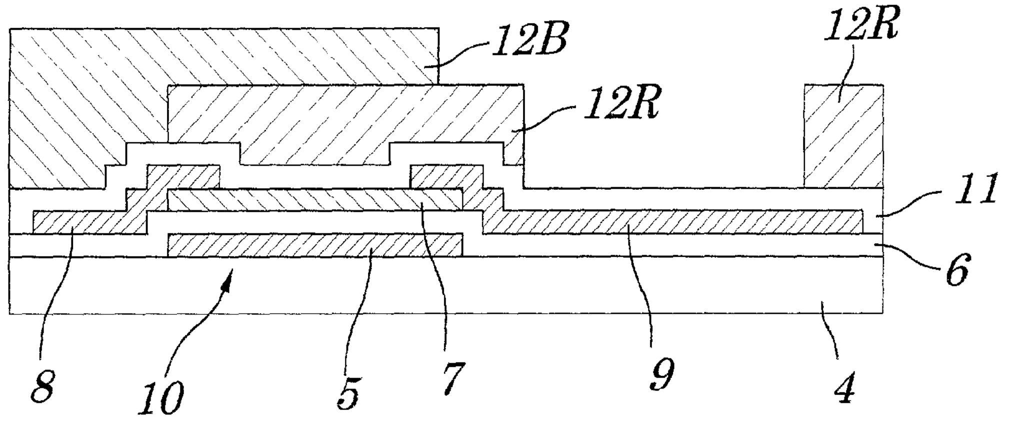


FIG.5E

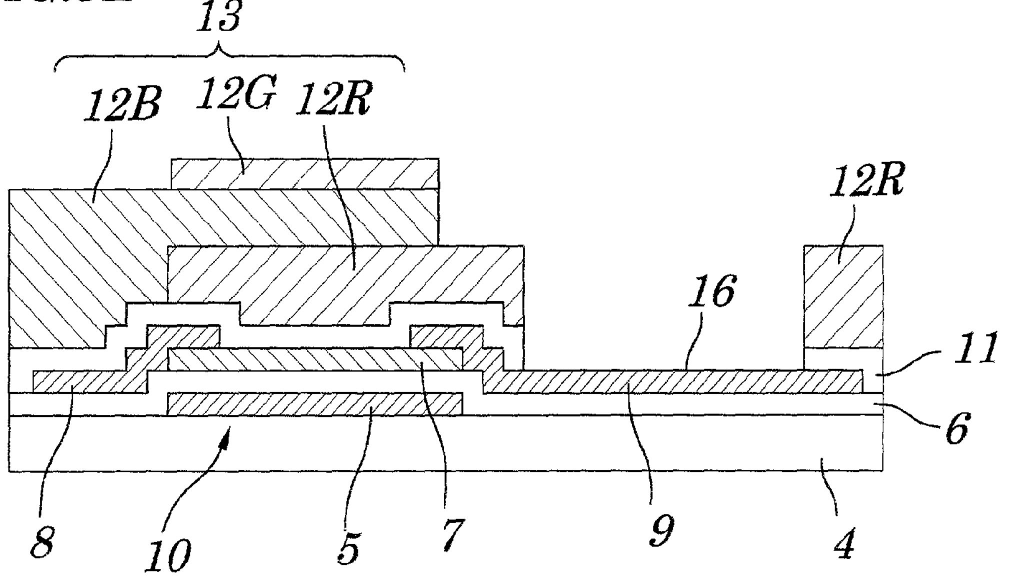


FIG.5F

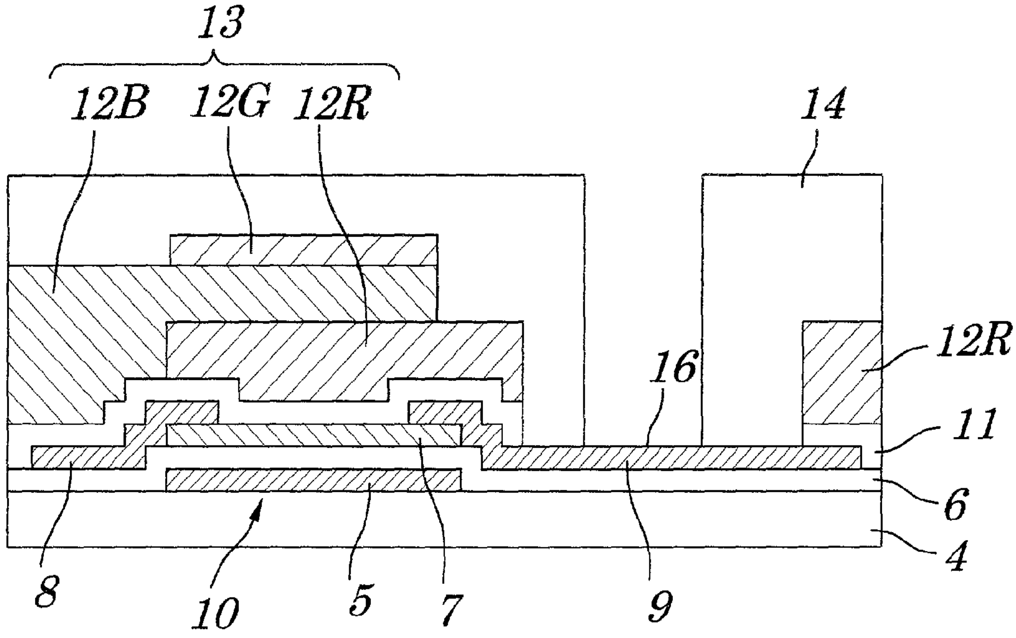


FIG.5G

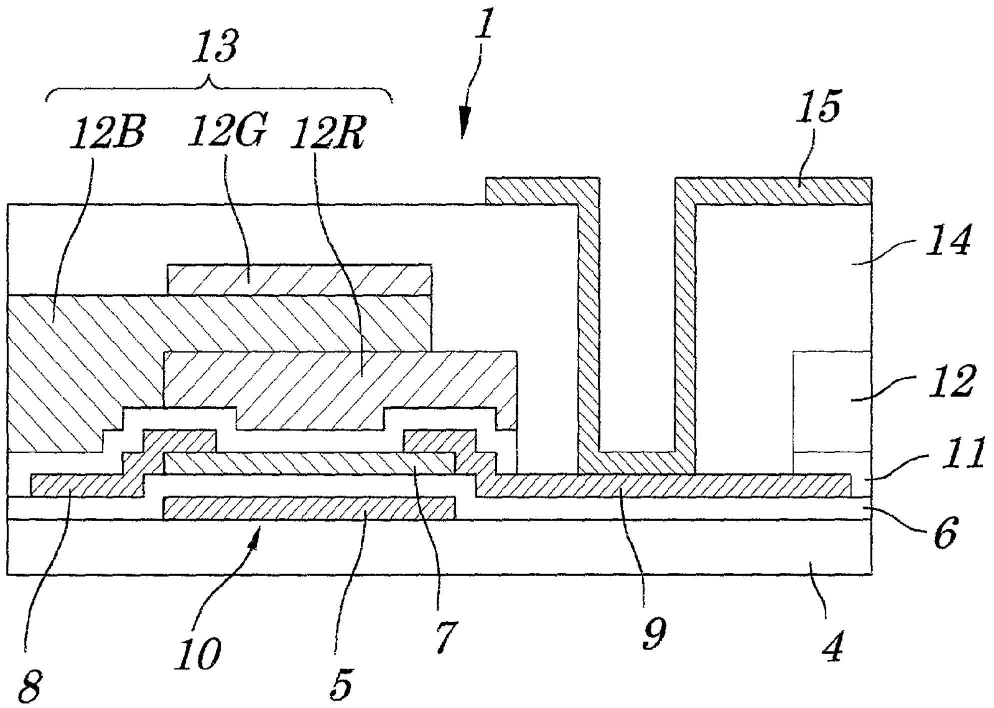


FIG.5H

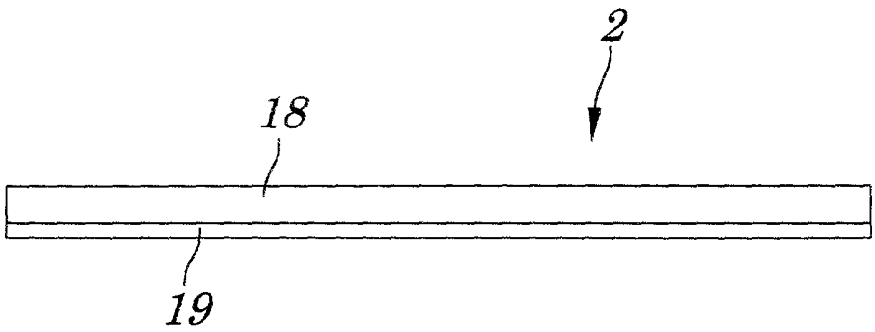
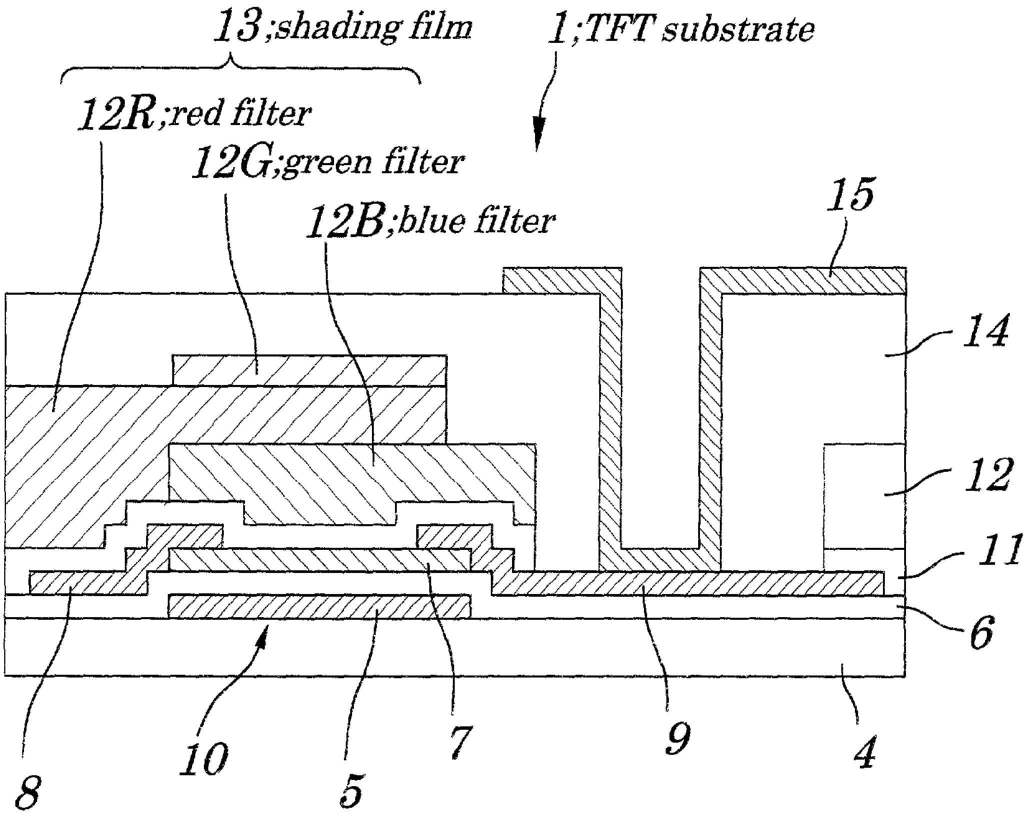


FIG.6


13;shading film
1;TFT substrate
12R;red filter
12G;green filter
12B;blue filter
15
14
12
11
6
4
9
7
5
10
8

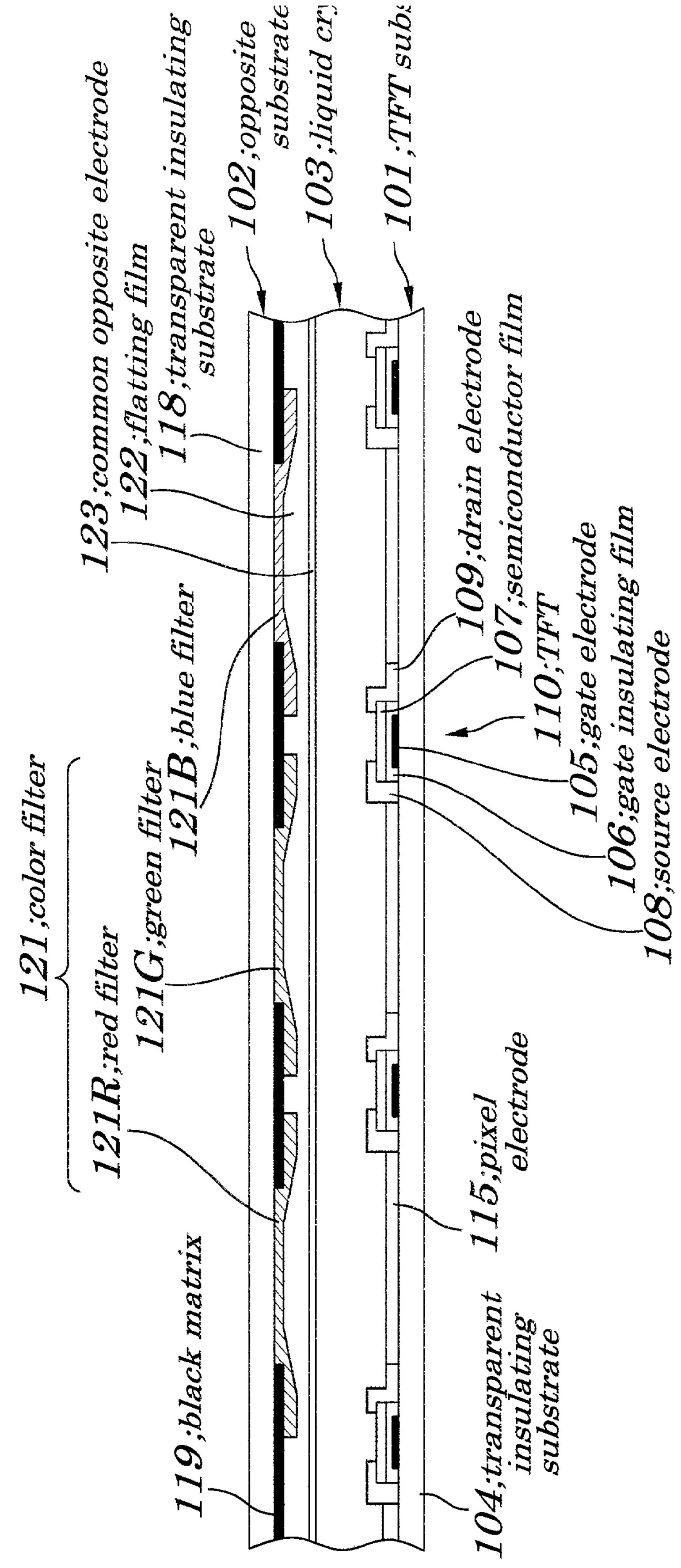


FIG. 7 (PRIOR ART)

FIG.8 (PRIOR ART)

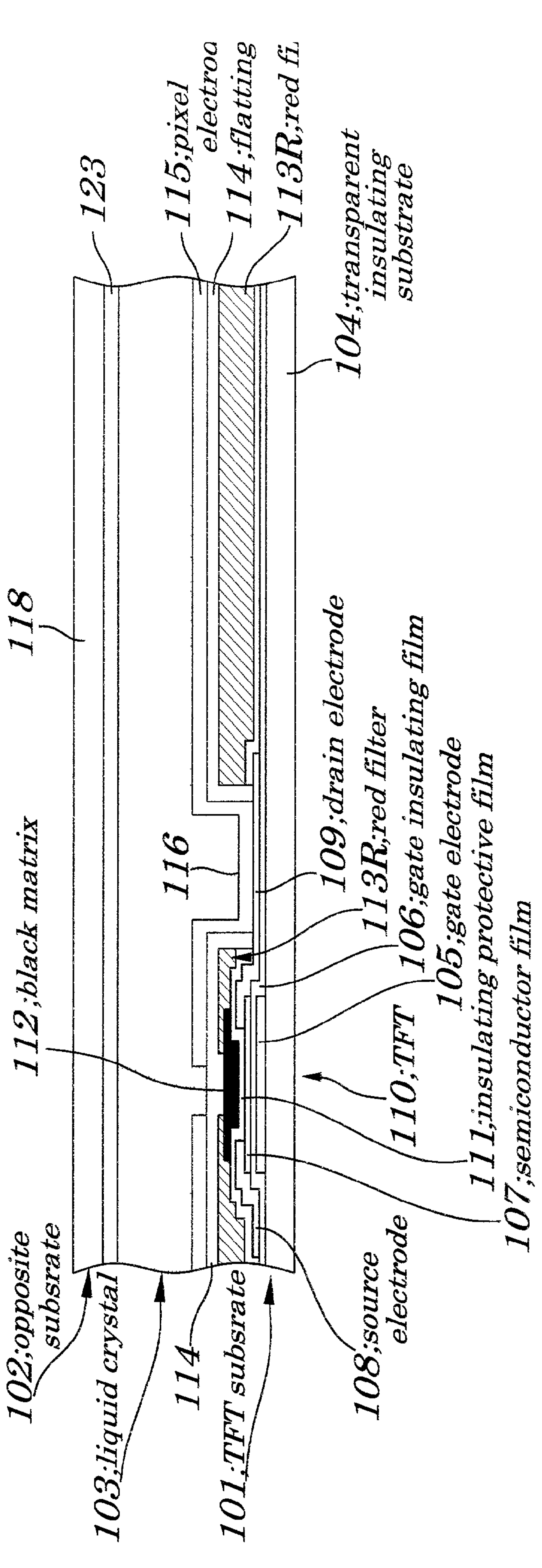


FIG.9 (PRIOR ART)

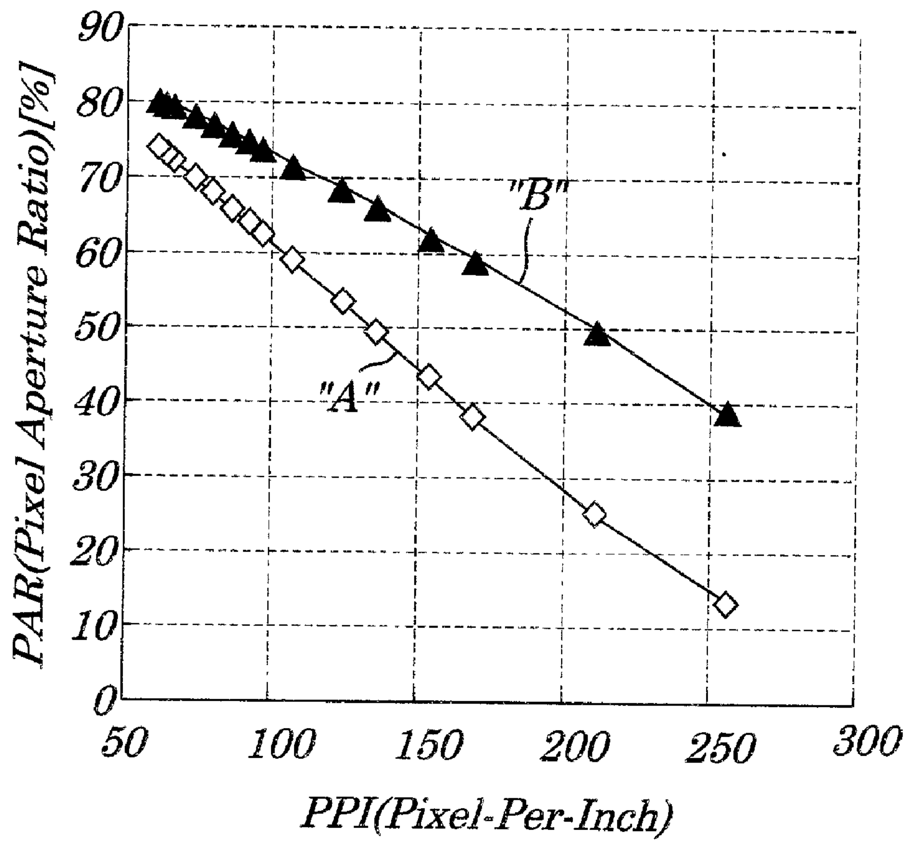


FIG. 10A (PRIOR ART)

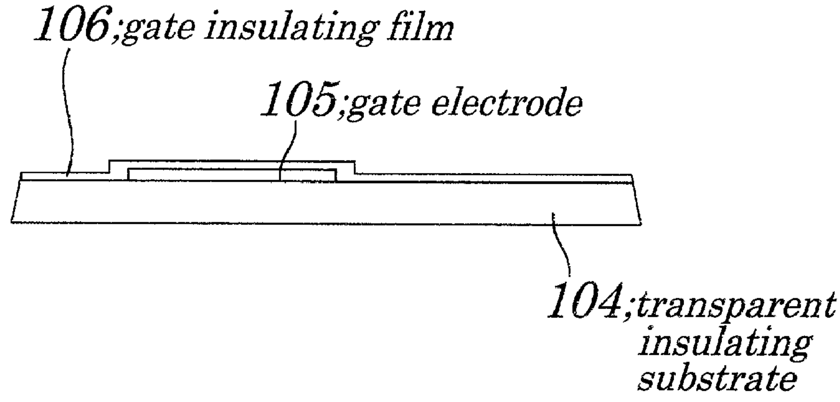


FIG. 10B (PRIOR ART)

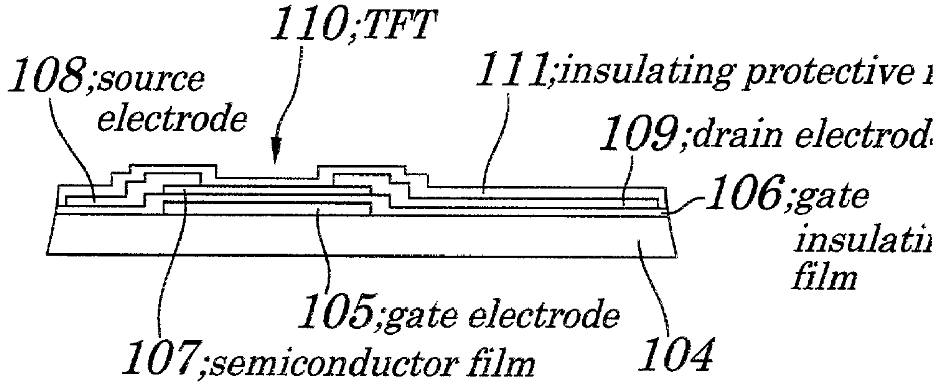


FIG. 10C (PRIOR ART)

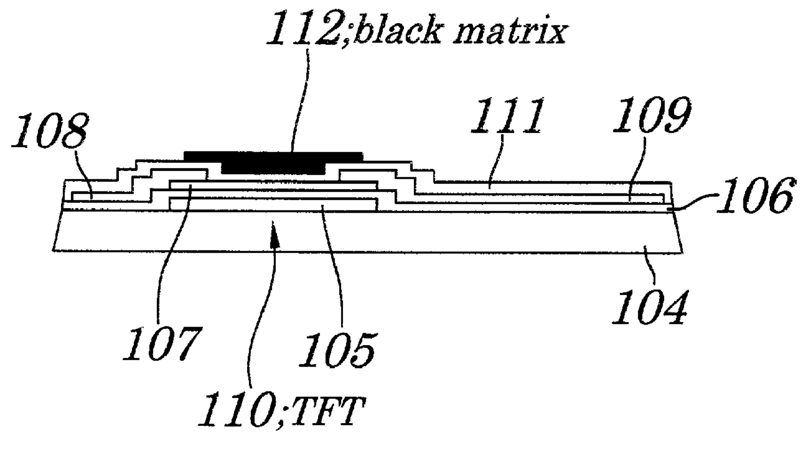


FIG.10D (PRIOR ART)

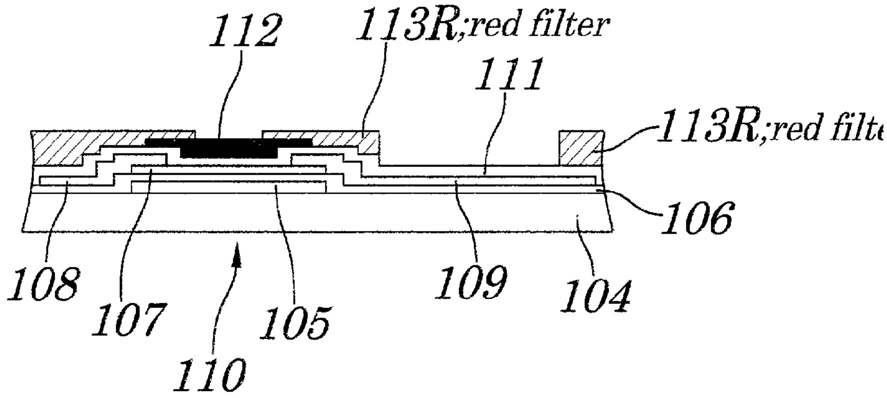


FIG.10E (PRIOR ART)

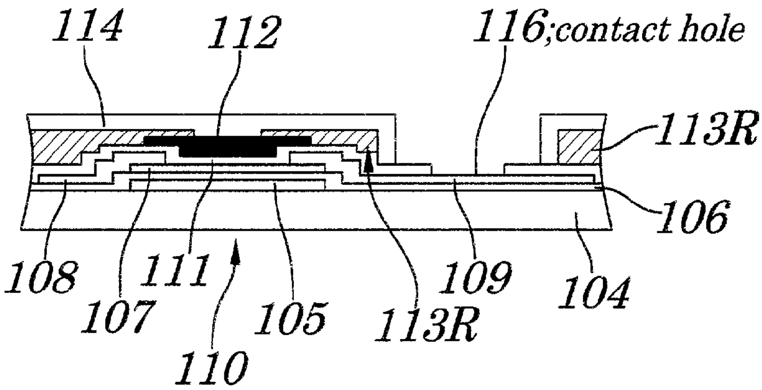


FIG.10F (PRIOR ART)

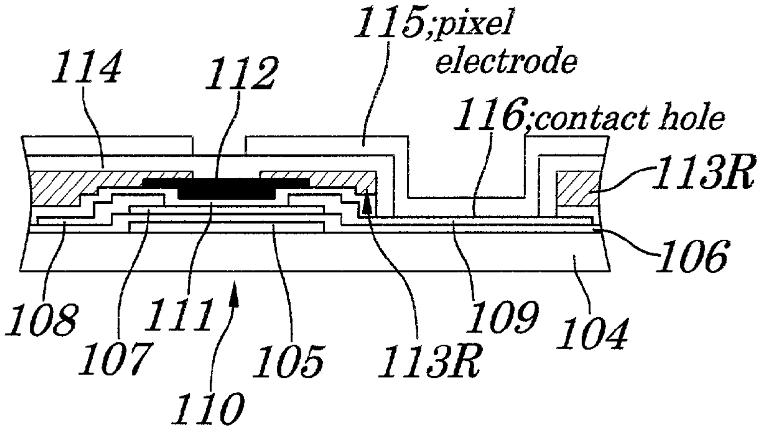


FIG. 11 (PRIOR ART)

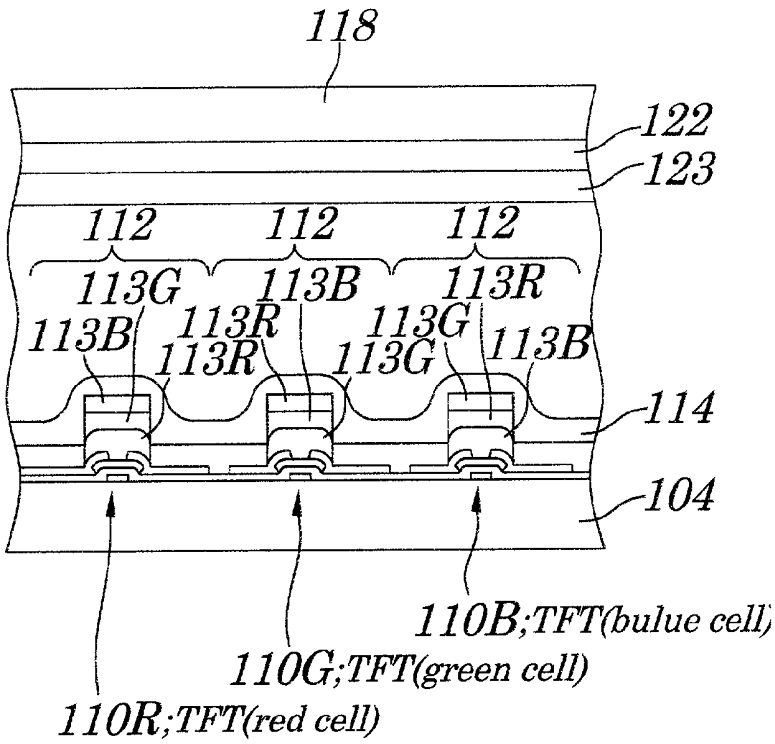
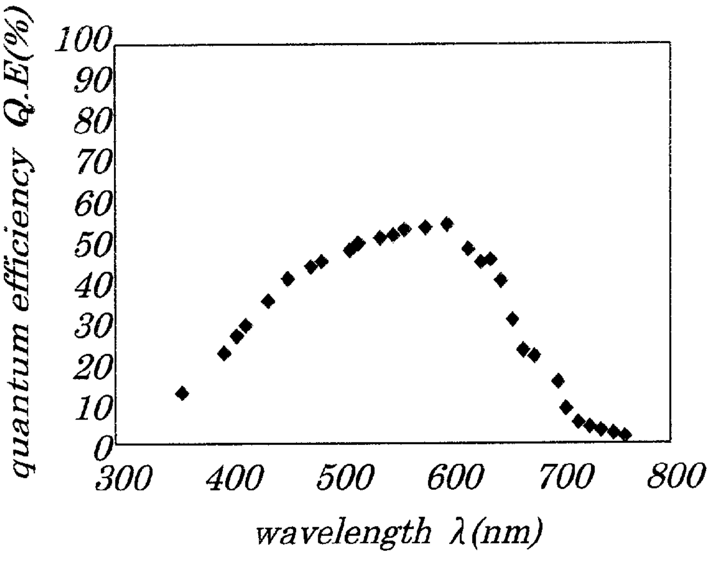


FIG. 12 (PRIOR ART)



COLOR LIQUID CRYSTAL DISPLAY AND METHOD OF MANUFACTURING COLOR LIQUID CRYSTAL DISPLAY

[0001] The present application claims priority of Japanese Patent Application No. Hei 11-368304 filed on Dec. 24, 1999, which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a color liquid crystal display and a method of manufacturing the color liquid crystal display and more particularly to a color liquid crystal display and a method of manufacturing the color liquid crystal display in which a color filter and a shading film are formed in a TFT (Thin Film Transistor) substrate.

[0004] 2. Description of the Related Art

[0005] A color liquid crystal display is generally used as a display for various information apparatuses or a like.

[0006] **FIG. 7** is a cross-sectional view showing a schematic configuration of a conventional color liquid crystal display. The color liquid crystal display, as shown in **FIG. 7**, is provided with a TFT substrate **101** in which a TFT operating as a switching element (driving element) for driving a liquid crystal **103** is formed, an opposite substrate **102** and the liquid crystal **103** held between the TFT substrate **101** and the opposite substrate **102**.

[0007] The TFT substrate **101**, as shown in **FIG. 7**, is provided with a transparent insulating substrate **104**, a gate electrode **105** formed from AL (aluminum), Mo (molybdenum), Cr (chromium) or a like on the transparent insulating substrate **104**, a gate insulating film **106** formed from Si_3N_4 (silicon nitride) or a like on the gate electrode **105**, a semiconductor film **107** formed from amorphous silicon or a like on the gate insulating film **106** over the gate electrode **105**, a source electrode **108** and a drain electrode **109** respectively led from both sides of the semiconductor film **107** and formed from Mo, Cr or a like, and a pixel electrode **115** connected to the drain electrode **109** and formed from ITO (Indium Tin Oxide) or a like. A TFT **110** is provided with the gate electrode **105**, the gate insulating film **106**, a semiconductor film **107**, the source electrode **108** and the drain electrode **109**.

[0008] The opposite substrate **102** is provided with a transparent insulating substrate **118** formed from glass or a like, a black matrix **119** formed at an opposite side of the TFT **110** as a shading film used to prevent a light from going into the TFT **110** or to shade a light from going into an unrelated part for display, a color filter **121** including a red filter **121**R, a green filter **121**G and a blue filter **121**B which are respectively formed at opposite sides of the pixel electrodes **115** in the TFT substrate **101**, a flatting film (overcoat film) **122** covering the red filter **121**R, the green filter **121**G and the blue filter **121**B and a common opposite electrode **123** covering the flatting film **122** and formed from ITO or the like. The flatting film **122** is provided in order to prevent a harmless material such as ion from mixing with the liquid crystal **103** via the red filter **121**R, the green filter **121**G, the blue filter **121**B or a like, and to so as to flatten the substrates of these filters **121**R, **121**G, **121**B.

[0009] The above-mentioned conventional color liquid crystal display has an advantage in a manufacturing process since the black matrix **119**, the red filter **121**R, the green filter **121**G and the blue filter **121**B are formed in the opposite substrate **102** in which no TFT **110** is formed. However, it is necessary to adjust the black matrix **119**, the red filter **121**R, the green filter **121**G and the blue filter **121**B in the opposite substrate **102** so as to be arranged at predetermined positions to the TFT substrate **101** when the color liquid crystal display is assembled by putting the liquid crystal **103** between the TFT substrate **101** and the opposite substrate **102**. Thus, it is necessary to keep a margin while considering a difference between the TFT substrate **101** and the opposite substrate **102**, and therefore, an pixel aperture ratio becomes small for the margin. As a result, it is impossible to avoid a luminance deterioration.

[0010] Thus, in order to avoid a deterioration of the pixel aperture ratio, another color liquid crystal display shown in **FIG. 8** is provided in which a black matrix **112** and a color filter are formed in the TFT substrate **101**.

[0011] The other conventional liquid crystal display, as shown in **FIG. 8**, is provided with the TFT substrate **101** in which a TFT operating as a switching element for driving a liquid crystal **103**, an opposite substrate **102** and the liquid crystal **103** held between the TFT substrate **101** and the opposite substrate **102**.

[0012] The TFT substrate **101**, as shown in **FIG. 8**, is provided with a transparent insulating substrate **104** formed from glass or a like, a gate electrode **105** formed from AL, Mo, Cr or a like on the transparent insulating substrate **104**, a gate insulating film **106** formed from Si_3N_4 or a like on the gate electrode **105**, a semiconductor film **107** formed from amorphous silicon or a like on the gate insulating film **106** over the gate electrode **105**, a source electrode **108** and a drain electrode **109** respectively led from both sides of the semiconductor film **107** and formed from Mo, Cr or a like, and an insulating protective film **111** covering the source electrode **108**, the semiconductor film **107** and the drain electrode **109** and formed from Si_3N_4 or a like. A TFT **110** is provided with the gate electrode **105**, the gate insulating film **106**, the semiconductor film **107**, the source electrode **108** and the drain electrode **109**.

[0013] Further, the TFT substrate **101** is provided with the black matrix **112** formed on the insulating protective film **111** as a shading film used to prevent a light from going into the TFT **110** or to shade a light from going into an unrelated part for display, the color filter including a red filter **113**R, a green filter **113**G and a blue filter **113**B (only the red filter **113**R is shown) which are respectively formed on the insulating protective film **111**, a flatting film (overcoat film) **114** covering the black matrix **112** and the color filter **113** and formed from photosensitive resist and a pixel electrode **115** formed so as to be connected to the drain electrode **109** on the flatting film **114** and formed from ITO or the like.

[0014] With the conventional color liquid crystal display as shown in **FIG. 8**, it is unnecessary to keep the margin for the difference between the TFT substrate **101** and the opposite substrate **102** when the liquid crystal display is manufactured by putting the liquid crystal **103** between the TFT substrate **101** and the opposite substrate **102** as shown in **FIG. 7**, since the black matrix **112** and the color filter **113** (the red filter **113**R, the green filter **113**G and the blue filter **113**B) are formed in the TFT substrate **101** having the TFT **110**. As a result, it is possible to increase a pixel aperture ratio and to avoid a luminance deterioration, and therefore, it is possible to produce a bright display.

[0015] **FIG. 11** is a graph showing a relationship between a number of pixels, namely, a PPI (Pixel Per Inch) and a PAR (Pixel Aperture Ratio) in the conventional liquid crystal display shown in **FIG. 7** and the conventional liquid crystal display shown in **FIG. 8**. A characteristic "A" shows a relationship in the conventional liquid crystal display shown in **FIG. 7**. A characteristic B shows a relationship in the conventional liquid crystal display shown in **FIG. 8**. As understood from **FIG. 9**, the conventional liquid crystal display shown in **FIG. 8** in which the black matrix **112** and the color filter are formed in the TFT substrate **101** can keep the PAR larger than the conventional liquid crystal display shown in **FIG. 7** in which the black matrix **119** and the color filter **121** are formed in the opposite substrate **102**.

[0016] Next, explanations will be given of a method of manufacturing the color liquid crystal display shown in **FIG. 8** in order of processes with reference to **FIG. 10A** to **FIG. 10F**.

[0017] First, as shown in **FIG. 10A, a** conductive film having a thickness of 100 nm to 300 nm and formed from Al, Mo, Cr or a like is formed on a whole upper surface of the transparent insulating substrate **104** formed from glass or a like using a sputtering technique, and then the gate electrode **105** is formed by patterning the conductive film using a known lithography technique. Then, the gate insulating film **106** having a thickness of 200 nm to 400 nm and formed from Si_3N_4 or a like is formed over the whole upper surface of the transparent insulating substrate **104** using a CVD (Chemical Vapor Deposition) technique.

[0018] Next, as shown in **FIG. 10B, a** semiconductor film having a thickness of 100 nm to 400 nm and formed from amorphous silicon or a like is formed over the whole upper surface of the transparent insulating substrate **104** using the CVD technique is formed, and then the semiconductor film **107** is formed by patterning the semiconductor film using the lithography technique. Then, a conductive film having a thickness of 100 nm to 300 nm and formed from Al, Mo, Cr or a like is formed over the whole upper surface of the transparent insulating substrate **104** using the sputtering technique, and then the source electrode **108** and the drain electrode **109** are formed by patterning the conductive film using the lithography technique. Then, the insulating protective film **111** having a thickness of 200 nm to 400 nm and formed from Si_3N_4 or a like is formed over the whole upper surface using the CVD technique.

[0019] With these processes, the TFT **110** is formed in which the gate electrode **105**, the gate insulating film **106**, the semiconductor film **107**, the source electrode **108** and the drain electrode **109** are formed on the transparent insulating substrate **104**.

[0020] Next, as shown in **FIG. 10C, a** black resist film in which black pigments are dispersed to acrylic photosensitive resist or a like is coated over the whole upper surface of the transparent insulating substrate **104** using a spin coating technique, and then the black matrix **112** having a thickness of 1.2 μm to 1.5 μm is formed so as to cover the upper surface of the TFT **110** by patterning the black resist film using the lithography technique.

[0021] Then, as shown in **FIG. 10D, a** red resist film in which red pigments are dispersed within an acrylic photosensitive resist or a like is coated over the whole upper surface using the spin coating technique, and then a red filter **113**R having a thickness of 1.0 μm to 1.2 μm is formed at pixel positions for red cells by patterning the red resist film using the lithography technique. Similarly, a green resist film in which green pigments are dispersed within an acrylic photosensitive resist or a like is coated over the whole upper surface using the spin coating technique, and then a green filter **113**G (not shown) having a thickness of 1.0 μm to 1.2 μm is formed at pixel positions for green cells by patterning the green resist film using the lithography technique. Also, a blue resist film in which blue pigments are dispersed within an acrylic photosensitive resist or a like is coated over the whole upper surface using the spin coating technique, and then a blue filter **113**B (not shown) having a thickness of 1.0 μm to 1.2 μm is formed at pixel positions for red cells by patterning the blue resist film using the lithography technique. With these processes, the color filter (a red filter **113**R is shown in **FIG. 10D**) is formed on the insulating protective film **111**.

[0022] Then, as shown in **FIG. 10E, a** positive acrylic photosensitive resist film having a thickness of 2 μm to 3 μm is coated over the whole upper surface using the spin coating technique, and then the flatting film **114** making a part of the insulating protective film **111** exposed is formed. Then, the contact hole **116** exposing the drain electrode **109** to the insulating protective film **111** is selectively formed.

[0023] Then, as shown in **FIG. 10F, a** conductive film formed from ITO or a like is formed over the whole upper surface including the contact hole **116**, and then the pixel electrode **115** having a thickness of 80 nm to 100 nm by patterning the conductive film using a photolithography technique. With these processes, TFT substrate **101 (FIG. 8)** is formed.

[0024] Next, the liquid crystal **103** is put between the TFT substrate **101** and the opposite substrate **102** obtained by the above-mentioned processes, and thereby the color liquid crystal display shown in **FIG. 8** is made.

[0025] Now, the above-mentioned method of manufacturing the color liquid crystal display has a disadvantage in that a number of processes increases and increment of a cost can not be avoided, since the black matrix **112** is formed in the process separated from the forming process for the color filter **113**. Also, a negative photosensitive resist film is usually used as the black matrix **112**, however, a light hardly passes through the negative photosensitive resist. Thus, though an amount of exposure is increased, a photo-cross-link occurs only at the surface, therefore, a defect often occurs in which the black matrix **112** comes off during manufacture.

[0026] For example, Japanese Patent Application Laid-open No. Sho 62-250416 discloses a color liquid crystal display in which a black matrix **112** and a color filter are formed in a same forming process. The color liquid crystal display, as shown in **FIG. 11**, on a surface of a TFT **110**R for a red cell to form a red filter **113**R, a green filter **113**G and a blue filter **113**B are successively formed so as to be laminated. On a surface of the TFT **110**G for a green cell to form the green filter **113**G, the blue filter **113**B and the red filter **113**R are successively formed so as to be laminated. On a surface of the TFT **110**B for the blue cell to form the blue filter **113**B, the red filter **113**R and the green filter **113**G are successively formed so as to be laminated. Other parts are similar to those in **FIG. 8**, therefore, same numeral numbers are applied to those in **FIG. 11** and explanations are omitted.

[0027] In the above-mentioned color liquid crystal display, since the black matrix **112** formed by laminating three layers, namely, the red filter **113**R, the green filter **113**G and the blue filter **113**B, on all the TFT **110**R for the red cell, the TFT **110**G for the green cell and the TFT **110**B for the blue cell, it is possible to form the black matrix **112** at a same time of forming the color filter **113**.

[0028] However, the conventional color liquid crystal display has a problem in that an optical leak of a TFT increases since a black matrix is formed by merely laminating a red filter, a green filter, and blue filter.

[0029] In other words, when the black matrix is formed by laminating the red filter, the green filter, and the blue filter, each of the red filter, the green filter, and the blue filter is formed by coating each color resist film using a spin coating technique and then by executing a known photolithography technique including an exposure process, a developing process, a burning process, and a like. The present inventor found that a third layer color filter (such as a blue filter) is much thinner than a first layer color filter (such as a red filter) at each filter-laminated part. As a result, since shading of the TFT becomes insufficient caused by an order of forming each filter or a thickness of each filter, it is possible to avoid increment of the optical leak.

[0030] **FIG. 12** is a graph showing a relationship between a wavelength λ (horizontal axis) of amorphous silicon forming the TFT formed on a TFT substrate and a QE (Quantum Efficiency) (vertical axis). **FIG. 12** shows that a sensitivity is high to an amorphous silicon concerning a wavelength of a large QE, and a current flows easily. Therefore, understood from **FIG. 12, a** wavelength from 500 nm to 650 nm has highest sensitivity and wavelength in this range becomes green. That is, concerning the TFT formed from the amorphous silicon, the optical leak increases extremely when the green light is illuminated. However, concerning blue light in a range of short wavelengths and red light in a range of long wavelengths, QE is smaller than that of the green light, therefore, though the blue light or the red light is illuminated to the TFT, increment of the optical leak is reduced more than the green light.

[0031] As described above, though the black matrix is formed by merely laminating the red filter, the green filter and the blue filter as the conventional color liquid crystal display, in a case in that the black matrix is formed so as to receive a large quantity of the green light, increment of the optical leak can not avoided. As undesirable configurations, there is a configuration in which the green filter is formed directly on the TFT, and a configuration in which a thickness of the green filter is thick not formed directly on the TFT, and a like.

SUMMARY OF THE INVENTION

[0032] In view of the above, it is an object of the present invention to provide a color liquid crystal display and a method of manufacturing the color liquid crystal display capable of reducing increment of an optical leak in a TFT when a shading film is formed by laminating plural filters to be a color filter.

[0033] According to a first aspect of the present invention, there is provided a color liquid crystal display in which a liquid crystal is put between a TFT substrate and an opposite substrate, the color liquid crystal display including:

[0034] a shading film including a first filter formed from one of a red resist film and a blue resist film and a second filter formed from another of the red resist film and the blue resist film and laminated on the first filter and being formed in the TFT substrate; and

[0035] a color filter including the red resist film and the blue resist film.

[0036] Also, according to a second aspect of the present invention, there is provided a color liquid crystal display in which a liquid crystal is put between a TFT substrate and an opposite substrate, the color liquid crystal display including:

[0037] a shading film including a first filter formed from one of a red resist film and a blue resist film, a second filter formed from another of the red resist film and the blue resist film and laminated on the first filter and a third filter formed from a green resist film and laminated on the second filter over the first filter and being formed in the TFT substrate; and

[0038] a color filter including the red resist film, the blue resist film and the green resist film.

[0039] In context with the foregoing, a preferable mode is one wherein the shading film is formed to cover a surface of a liquid crystal driving element formed in the TFT substrate.

[0040] Another preferable mode is one wherein the third filter is thinnest among the first filter, the second filter and the third filter forming the shading film.

[0041] A further preferable mode is one wherein the first filter, the second filter and the third filter are formed from pigment-dispersed photosensitive resist.

[0042] According to a third aspect of the present invention, there is provided a method of manufacturing a color liquid crystal display in which a liquid crystal is put between a TFT substrate and an opposite substrate and a color filter and a shading film including plural unit filters are laminated on the TFT substrate; the method including;

[0043] a step of forming plural liquid crystal driving elements on the TFT substrate;

[0044] a step of sequentially forming the plural unit filters on surfaces of the liquid crystal driving elements; and

[0045] a step of forming a green filter at last.

[0046] Furthermore, according to a fourth aspect of the present invention, there is provided a method of manufacturing a color liquid crystal display in which a liquid crystal is put between a TFT substrate and an opposite substrate and a color filter and a shading film including plural unit filters are laminated on the TFT substrate; the method including;

[0047] a liquid crystal driving element forming step of forming plural liquid crystal driving elements on the TFT substrate;

[0048] a first filter forming step of forming a first filter formed from one of a red filter and a blue filter on an insulating protective film after covering the liquid crystal driving elements with the insulating protective film;

[0049] a first patterning step of patterning the first filter so as to be left at a first pixel position and surfaces of the liquid crystal driving elements;

[0050] a second filter forming step of forming a second filter formed from another of the red filter and the blue filter on a whole surface including the first filter;

[0051] a second patterning step of patterning the second filter so as to be left at a second pixel position and on the first filter;

[0052] a third filter forming step of forming a third filter formed from a green filter on a whole surface including the first filter and the second filter; and

[0053] a third patterning step of patterning the third filter so as to be left at a third pixel position and on the second filter.

[0054] In context with the foregoing, a preferable mode is one further including:

[0055] a flatting film through hole forming step of forming a flatting film on a whole surface including the third filter and of forming a through hole making an electrode of the liquid crystal driving element exposed by patterning the flatting film successively in the third patterning step.

[0056] Another preferable mode is one further including:

[0057] a pixel electrode forming step of forming a pixel electrode for connecting the through hole to the electrode successively in the flatting film through hole forming step.

[0058] A further preferable mode is one wherein as the red filter, the blue filter and the green filter; red-pigment dispersed photosensitive resist, blue-pigment dispersed photosensitive resist, green-pigment dispersed photosensitive resist are respectively used.

[0059] With the above configurations, a shading film including a first filter which is a red resist film or a blue resist film, a second filter which is a red resist film laminated on the first filter and a third filter which is a green resist film laminated on the first filter and the second filter is formed, therefore, it is possible to shade a green light of a wavelength having a largest QE.

[0060] Also, with this method, it is possible to form a shading film at a same time of a process of forming a red filter, a blue filter and a green filter, therefore, it is possible to avoid increment of a cost since a number of processes of forming the shading film does not increase.

[0061] Therefore, it is possible to restrict increment of an optical leak in the TFT when the shading film is formed by laminating plural filters to be a color filter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0062] The above and other objects, advantages, and features of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings in which:

[0063] **FIG. 1** is a plan view showing a configuration of a color liquid crystal display according to a first embodiment of the present invention;

[0064] **FIG. 2** is a cross-sectional view showing a part indicated by arrows A in **FIG. 1**;

[0065] **FIG. 3A** to **FIG. 3C** are schematic views showing processes of forming a main part of the color liquid crystal display according to the first embodiment of the present invention;

[0066] **FIG. 4** is a graph showing a relationship between an applied voltage to a TFT (horizontal axis) and a leak current (vertical axis) in the color liquid crystal display according to the first embodiment and a second embodiment of the present invention;

[0067] **FIG. 5**A, **FIG. 5**B and **FIG. 5C** are process views showing a method of the manufacturing color liquid crystal display in an order of processes according to the first embodiment of the present invention;

[0068] **FIG. 5**D, **FIG. 5**E and **FIG. 5F** are process views showing the method of manufacturing the color liquid crystal display in the order of processes according to the first embodiment of the present invention;

[0069] **FIG. 5**G and **FIG. 5H** are process views showing the method of manufacturing the color liquid crystal display in the order of processes according to the first embodiment of the present invention;

[0070] **FIG. 6** is a cross-sectional view showing a configuration of a color liquid crystal display according to the second embodiment of the present invention;

[0071] **FIG. 7** is a cross-sectional view showing a configuration of a conventional color liquid crystal display;

[0072] **FIG. 8** is a cross-sectional view showing a configuration of another conventional color liquid crystal display;

[0073] **FIG. 9** is a graph showing a relationship between a PPI (Pixel Per Inch) (horizontal axis) and a PAR (Pixel Aperture Ratio) (vertical axis) in the conventional color liquid crystal display;

[0074] **FIG. 10**A, **FIG. 10**B and **FIG. 10C** are process views showing a conventional method of manufacturing the conventional color liquid crystal display in an order of processes;

[0075] **FIG. 10**D, **FIG. 10**E and **FIG. 10**F are process views showing the conventional method of manufacturing the conventional color liquid crystal display in the order of processes;

[0076] **FIG. 11** is a cross-sectional view showing a configuration of the conventional color liquid crystal display; and

[0077] **FIG. 12** is a graph showing a relationship between a wavelength λ (horizontal axis) and a QE (Quantum Efficiency) of amorphous silicon forming a TFT in the conventional color liquid crystal display.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0078] Best modes for carrying out the present invention will be described in further detail using various embodiments with reference to the accompanying drawings.

First Embodiment

[0079] **FIG. 1** is a plan view showing a configuration of a color liquid crystal display according to a first embodiment of the present invention, **FIG. 2** is a cross-sectional view showing a part indicated by arrows A in **FIG. 1**, **FIG. 3**A to **FIG. 3**C are schematic views showing processes of forming a main part of the color liquid crystal display, **FIG. 4** is a graph showing a relationship between an applied voltage to a TFT (horizontal axis) and a leak current (vertical axis) in the color liquid crystal display and **FIG. 5**A to **FIG. 5**H are process views showing a method of manufacturing the color liquid crystal display in an order of processes.

[0080] The color liquid crystal display, as shown in **FIG. 2**, is provided with a TFT substrate **1** including a TFT **10** operating as a switching element for driving a liquid crystal **3**, an opposite substrate **2** and the liquid crystal **3** put between the TFT substrate **1** and the opposite substrate **2**.

[0081] The TFT substrate **1** is provided with a transparent insulating substrate **4** formed from glass or a like, a gate electrode **5** having a thickness of 100 nm to 300 nm and formed from AL (aluminum), Mo (molybdenum), Cr (chromium) or a like on the transparent insulating substrate **4**, a gate insulating film **6** having a thickness of 200 nm to 400 nm and formed from Si_3N_4 (silicon nitride) or a like on the gate electrode **5**, a semiconductor film **7** having a thickness of 100 nm to 400 nm and formed from amorphous silicon or a like on the gate insulating film **6** over the gate electrode **5**, a source electrode **8** and a drain electrode **9** having respective thickness of 100 nm to 300 nm, respectively led from both sides of the semiconductor film **7** and formed from Mo, Cr or a like and an insulating protective film **11** having a thickness of 200 nm to 400 nm and formed from Si_3N_4 to cover the source electrode **8** and the drain electrode **9**. The TFT **10** is provided with the gate electrode **5**, the gate insulating film **6**, the semiconductor film **7**, the source electrode **8** and the drain electrode **9**.

[0082] Further, the TFT substrate **1** is provided with a color filter **12** including a red filter **12**R, a green filter **12**G and a blue filter **12**B, each of which has a thickness of 1.4 μm to 1.6 μm, on the insulating protective film **11**, a shading film **13** formed on the insulating protective film **11** and used to prevent a light from going into the TFT **10** or to shade the light going into an unrelated part for display, a flatting film **14** covering the color filter **12** and the shading film **13**, formed from photosensitive resist or a like and having a thickness of 2.0 μm to 4.0 μm and a pixel electrode **15** formed so as to be connected to the drain electrode **9** on the flatting film **14**, formed from ITO or a like and having a thickness of 50 nm to 100 nm.

[0083] The opposite substrate **2** is provided with a transparent insulating substrate **18** formed from glass or a like and a common opposite electrode **19** formed from ITO or the like.

[0084] In the first embodiment, the shading film **13** covering a surface of the TFT **10** is formed by laminating the red filter **12**R of a first layer, the blue filter **12**B of a second layer and the green filter **12**G of a third layer. Therefore, though each of the red filter **12**R, the green filter **12**G and the blue filter **12**B has the thickness of 1.4 μm to 1.6 μm as described above, a laminated part has a thickness described as follows.

[0085] That is, the red filter **12**R of the first layer consists essentially of a red resist film having a thickness of 1.4 μm to 1.6 μm, in which red pigments are dispersed within an acrylic photosensitive resist. The blue filter **12**B of the second layer consists essentially of a blue resist film having a thickness of 0.9 μm to 1.1 μm, in which blue pigments are dispersed within an acrylic photosensitive resist. The green filter **12**G of the third layer consists essentially of a green resist film having a thickness of 0.3 μm to 0.5 μm, in which green pigments are dispersed within an acrylic photosensitive resist. Each of the red resist film **12**R, the blue resist film **12**B and the green resist film **12**G is coated by a spin coating technique as described later; and a later coated resist, the thinner.

[0086] **FIG. 3**A to **FIG. 3**C are schematic view showing a method of forming the red filter **12**R, the blue filter **12**B and the green filter **12**G by sequentially coating the red resist film, the blue resist film and the green resist film.

[0087] First, as shown in **FIG. 3**A, the red resist film having a thickness of 1.4 μm to 1.6 μm is coated on a whole surface of a substrate **17** using the spin coating technique, and then the red filter (first layer) having a same thickness is formed by patterning using a lithography technique.

[0088] Then, as shown in **FIG. 3**B, the blue resist film having a thickness approximately similar to that of the red resist film is coated on the whole surface using the spin coating technique as indicated by a dotted line. However, a part of the blue resist film flows out around caused by spin and the blue resist film becomes thinner, and then the blue filter (second layer) having a thickness of 0.9 μm to 1.6 μm is formed on the red filter **12**R.

[0089] Then, as shown in **FIG. 3**C, the green resist film having a thickness approximately similar to that of the red resist film is coated on the whole surface using the spin coating technique as indicated by a dotted line. However, the most of the blue resist film flows out around caused by spin and the green resist film becomes much thinner, and then the green filter (third layer) having a thickness of 0.3 μm to 0.5 μm is formed on the blue filter **12**B over the red filter **12**R. In other words, the green filter **12**G of the third layer is thinner than the red filter **12**R of the first layer and the blue filter **12**G of the second layer by a layer difference at the laminated part.

[0090] As described above, according to the first embodiment, the shading film **13** is formed by laminating the red filter **12**R, the blue filter **12**B and the green filter **12**G in order and thereby the green filter **12**G causing increment of the optical leak of the TFT **10** is formed at a position so as to be most separated from the TFT **10** and so as to be thinnest, therefore, it is possible to reduce the increment of the optical leak in the TFT **10**.

[0091] **FIG. 4** is a graph showing a relationship between an applied voltage VG (horizontal axis) and a leak current IS (vertical axis) of the TFT **10** on the TFT substrate **1** in which the shading film **13** is formed according to the first embodiment. A characteristic "A" represents a characteristic after irradiating and a characteristic "B" represent a characteristic before irradiating. As understood from **FIG. 4**, though the leak current increases after irradiating than before irradiating, the leak current is relatively restricted.

[0092] Next, explanations will be given of the method of manufacturing the color liquid crystal display in order of process with reference to **FIG. 5A** to **FIG. 5H**.

[0093] First, as shown in **FIG. 5A, a** conductive film formed from Al, Mo, Cr or a like is formed using a sputtering technique on the transparent insulating substrate **4** formed from glass or a like, and then the gate electrode **5** having a thickness of 100 nm to 300 nm is formed by patterning the conductive film using the known lithography technique. Then, the gate insulating film **6** having a thickness of 200 nm to 400 nm and formed from Si_3N_4 or a like is formed on the whole surface of the transparent insulating film **4** using a CVD (Chemical Vapor Deposition) technique. Then, as shown in **FIG. 5B, a** semiconductor film formed from amorphous silicon or a like is formed on the whole surface of the gate insulating film **6** using the CVD technique, and then the semiconductor film **7** having a thickness of 100 nm to 400 nm is formed by patterning the semiconductor film using the lithography technique. Then, a conductive film formed from Mo, Cr or a like is formed on the whole surface using the sputtering technique, and then the source electrode **8** and the drain electrode **9** having a thickness of 100 nm to 300 nm are formed by patterning the conductive film using the lithography technique. Then, the insulating protective film **11** having a thickness of 200 nm to 400 nm and formed from Si_3N_4 or a like is formed on the whole surface using the CVD technique.

[0094] With these processes, the TFT **10** including the gate electrode **5**, the gate insulating film **6**, the semiconductor film **7**, the source electrode **8** and the drain electrode **9** are formed on the transparent insulating substrate **4**.

[0095] Next, as shown in **FIG. 5C, a** red resist film in which red pigments are dispersed within an acrylic photosensitive resist or a like is coated on the whole surface using the spin coating technique, and then the red filter **12**R having a thickness of 1.4 μm to 1.6 μm is formed on all the surface of the TFT **10** at all pixel positions for red cells by patterning the red resist film using the lithography technique.

[0096] Then, as shown in **FIG. 5D, a** blue resist film in which blue pigments are dispersed within an acrylic photosensitive resist or a like is coated on the whole surface using the spin coating technique, and then the blue filter **12**B is formed on all the red filters **12**R of the surface of the TFT **10** at all desirable positions in which the blue filters must be formed by patterning the green resist film using the lithography technique. At this time, the blue filter **12**B having a thickness approximately similar to that of the red filter **12**R at the desirable position for blue cells, however, the blue filter **12**B having a thickness of 0.9 μm to 1.1 μm is formed on the red filter **12**R on the surface of the TFT **10** due to a reason explained with reference to **FIG. 3A** to **FIG. 3C**.

[0097] Then, as shown in **FIG. 5E, a** green resist film in which green pigments are dispersed within an acrylic photosensitive resist or a like is coated on the whole surface using the spin coating technique, and then the green filter **12**G is formed on all the blue filters **12**B of the surface of the TFT **10** at all desirable positions in which the green filters must be formed by patterning the green resist film using the lithography technique. At this time, the green filter **12**G having a thickness approximately similar to that of the red filter **12**R at the desirable position for green cells, however, the green filter **12**B having a thickness of 0.3 μm to 0.5 μm is formed on the blue filter **12**B on the surface of the TFT **10** due to the reason explained with reference to **FIG. 3A** to **FIG. 3C**.

[0098] Then, as shown in **FIG. 5F, a** positive acrylic photosensitive resist film having a thickness of 2 μm to 3 μm is coated on the whole surface using the spin coating technique, and then a flatting film **14** making a part of the insulating protective film **11** on the drain electrode **9** exposed is formed. Then, the contact hole **16** exposing the drain electrode **9** to the insulating protective film **11** is selectively formed.

[0099] Next, as shown in **FIG. 5G, a** conductive film having a thickness of 80 nm to 100 nm and formed from ITO or a like is formed on the whole surface including the contact hole **16**, and then the pixel electrode **15** having a thickness of 80 nm to 100 nm by patterning the conductive film using a photolithography technique. With these processes, the TFT substrate **1** is formed.

[0100] Then, as shown in **FIG. 5H, a** conductive film formed from ITO or a like is formed using the transparent insulating substrate **18** formed from glass or a like, and then the opposite electrode **19** is formed. With these processes, the opposite substrate **2** is formed.

[0101] Next, the liquid crystal **3** is put between the TFT substrate **1** and the opposite substrate **2** obtained by the above-mentioned processes, and thereby the color liquid crystal display shown in **FIG. 1** and **FIG. 2** is made.

[0102] As described above, according to the color liquid crystal display of the first embodiment, the shading film **13** includes a first filter which is the red filter **12**R, a second filter which is the blue filter **12**B laminated on the first filter and a third filter which is the green filter **12**G laminated on the first filter and the second filter, therefore, it is possible to shade green wavelength light having the largest QE.

[0103] Also, according to the color liquid crystal display of the first embodiment, it is possible to form the shading film **13** at a same process as the red filter **12**R, the blue filter **12**B and the green filter **12**G, therefore, it is possible to avoid increment of a cost since a number of processes for forming a shading film does not increase.

[0104] Therefore, it is possible to restrict increment of the optical leak of the TFT when the shading film is formed by laminating plural filters to be a color filter.

Second Embodiment

[0105] Further, a second embodiment according to the present invention will be described.

[0106] FIG. 6 is a cross-sectional view showing a configuration of a color liquid crystal display according to the second embodiment of the present invention. A difference between configuration of the first embodiment and that of the second embodiment is that an order of laminating a red filter and a blue filter to be a shading film is changed.

[0107] That is, in the second embodiment, as shown in FIG. 6, a blue filter 12B of a first layer is a blue resist film having a thickness of 1.4 μm to 1.6 μm, in which blue pigments are dispersed within an acrylic photosensitive resist or a like, a red filter 12R of a second layer is a red resist film having a thickness of 0.9 μ m to 1.1 μm, in which red pigments are dispersed within an acrylic photosensitive resist or a like and a green filter 12G of a third layer is a green resist film having a thickness of 0.3 μm to 0.5 μm, in which green pigments are dispersed within an acrylic photosensitive resist or a like.

[0108] In FIG. 4, a characteristic "C" represents a characteristic after irradiating and a characteristic "D" represents a characteristic before irradiating. As understood from FIG. 4, the leak current increases after irradiating than before irradiating, however, the leak current is relatively restricted and it is possible to obtain same effects as the first embodiment.

[0109] The second embodiment is similar to the first embodiment except for order of laminating. Thus, in FIG. 6, same numerals are given to parts corresponding to those in FIG. 1 and FIG. 2 and explanations thereof are omitted.

[0110] As described above, according to the second embodiment, it is possible to obtain effects approximately similar to effects of the first embodiment.

[0111] It is thus apparent that the present invention is not limited to the above embodiments but may be changed and modified without departing from the scope and spirit of the invention.

[0112] For example, it is unnecessary to use three filters, namely, a red filter, a blue filter and a green filter to form a shading film formed by laminating plural filters to be a color filter, and at least two filters, namely, a red filter and a blue filter may be laminated. Also, a TFT is used as a switching element for driving a liquid crystal in these embodiments, however, the present invention is not limited to this, another switching element such as a diode may be used.

[0113] Also, in these embodiments, a transparent insulating substrate is used as a TFT substrate and a switching element is formed on a semiconductor film formed on the transparent insulating substrate, however, the present invention is not limited to this, another substrate such as a semiconductor substrate, for example, a silicon substrate may be used and a switching element may be formed on this substrate. Also, conditions such as various insulating films, processes of forming a conductive film, a film thickness and a like are examples, and these conditions may be changed in accordance with a purpose, a use or a like.

What is claimed is:

1. A color liquid crystal display in which a liquid crystal is put between a TFT substrate and an opposite substrate, said color liquid crystal display comprising:

a shading film including a first filter formed from one of a red resist film and a blue resist film and a second filter formed from another of said red resist film and said blue resist film and laminated on said first filter and being formed in said TFT substrate; and

a color filter including said red resist film and said blue resist film.

2. The color liquid crystal display according to claim 1, wherein said shading film is formed to cover a surface of a liquid crystal driving element formed in said TFT substrate.

3. A color liquid crystal display in which a liquid crystal is put between a TFT substrate and an opposite substrate, said color liquid crystal display comprising:

a shading film including a first filter formed from one of a red resist film and a blue resist film, a second filter formed from another of said red resist film and said blue resist film and laminated on said first filter and a third filter formed from a green resist film and laminated on said second filter over said first filter and being formed in said TFT substrate; and

a color filter including said red resist film, said blue resist film and said green resist film.

4. The color liquid crystal display according to claim 3, wherein said shading film is formed to cover a surface of a liquid crystal driving element formed in said TFT substrate.

5. The color liquid crystal display according to claim 3, wherein said third filter is thinnest among said first filter, said second filter and said third filter forming said shading film.

6. The color liquid crystal display according to claim 4, wherein said third filter is thinnest among said first filter, said second filter and said third filter forming said shading film.

7. The color liquid crystal display according to claim 3, wherein said first filter, said second filter and said third filter are formed from pigment-dispersed photosensitive resist.

8. The color liquid crystal display according to claim 5, wherein said first filter, said second filter and said third filter are formed from pigment-dispersed photosensitive resist.

9. The color liquid crystal display according to claim 6, wherein said first filter, said second filter and said third filter are formed from pigment-dispersed photosensitive resist.

10. A method of manufacturing a color liquid crystal display in which a liquid crystal is put between a TFT substrate and an opposite substrate and a color filter and a shading film including plural unit filters are laminated on said TFT substrate; said method comprising;

a step of forming plural liquid crystal driving elements on said TFT substrate;

a step of sequentially forming said plural unit filters on surfaces of said liquid crystal driving elements; and

a step of forming a green filter at last.

11. The method of manufacturing the color liquid crystal display according to claim 10, wherein as said red filter, said blue filter and said green filter; red-pigment dispersed pho-

tosensitive resist, blue-pigment dispersed photosensitive resist, green-pigment dispersed photosensitive resist are respectively used.

12. A method of manufacturing a color liquid crystal display in which a liquid crystal is put between a TFT substrate and an opposite substrate and a color filter and a shading film including plural unit filters are laminated on said TFT substrate; said method comprising;

a liquid crystal driving element forming step of forming plural liquid crystal driving elements on said TFT substrate;

a first filter forming step of forming a first filter formed from one of a red filter and a blue filter on an insulating protective film after covering said liquid crystal driving elements with said insulating protective film;

a first patterning step of patterning said first filter so as to be left at a first pixel position and surfaces of said liquid crystal driving elements;

a second filter forming step of forming a second filter formed from another of said red filter and said blue filter on a whole surface including said first filter;

a second patterning step of patterning said second filter so as to be left at a second pixel position and on said first filter;

a third filter forming step of forming a third filter formed from a green filter on a whole surface including said first filter and said second filter; and

a third patterning step of patterning said third filter so as to be left at a third pixel position and on said second filter.

13. The method of manufacturing the color liquid crystal display according to claim 12, further comprising:

a flatting film through hole forming step of forming a flatting film on a whole surface including said third filter and of forming a through hole making an electrode of said liquid crystal driving element exposed by patterning said flatting film successively in said third patterning step.

14. The method of manufacturing the color liquid crystal display according to claim 13, further comprising:

a pixel electrode forming step of forming a pixel electrode for connecting said through hole to said electrode successively in said flatting film through hole forming step.

15. The method of manufacturing the color liquid crystal display according to claim 12, wherein as said red filter, said blue filter and said green filter; red-pigment dispersed photosensitive resist, blue-pigment dispersed photosensitive resist, green-pigment dispersed photosensitive resist are respectively used.

* * * * *

专利名称(译)	彩色液晶显示器和制造彩色液晶显示器的方法		
公开(公告)号	US20010005245A1	公开(公告)日	2001-06-28
申请号	US09/747062	申请日	2000-12-20
申请(专利权)人(译)	NEC公司		
当前申请(专利权)人(译)	NEC液晶技术有限公司.		
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发明人	SAKAMOTO, MICHIAKI YAMAMOTO, YUJI OKAMOTO, MAMORU		
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摘要(译)

在彩色液晶显示器中，遮光膜包括由红色抗蚀剂膜形成的第一滤光器，由层叠在第一滤光器上的蓝色抗蚀剂膜形成的第二滤光器和由层叠在第一滤光器上的绿色抗蚀剂膜形成的第三滤光器第二滤光器形成在TFT基板上。因此，当通过层叠多个滤光器作为滤色器形成遮光膜时，限制了TFT中光泄漏的增量。