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(54) TRANSFLECTIVE LIQUID CRYSTAL DISPLAY AND COLOR FILTER FOR THE SAME

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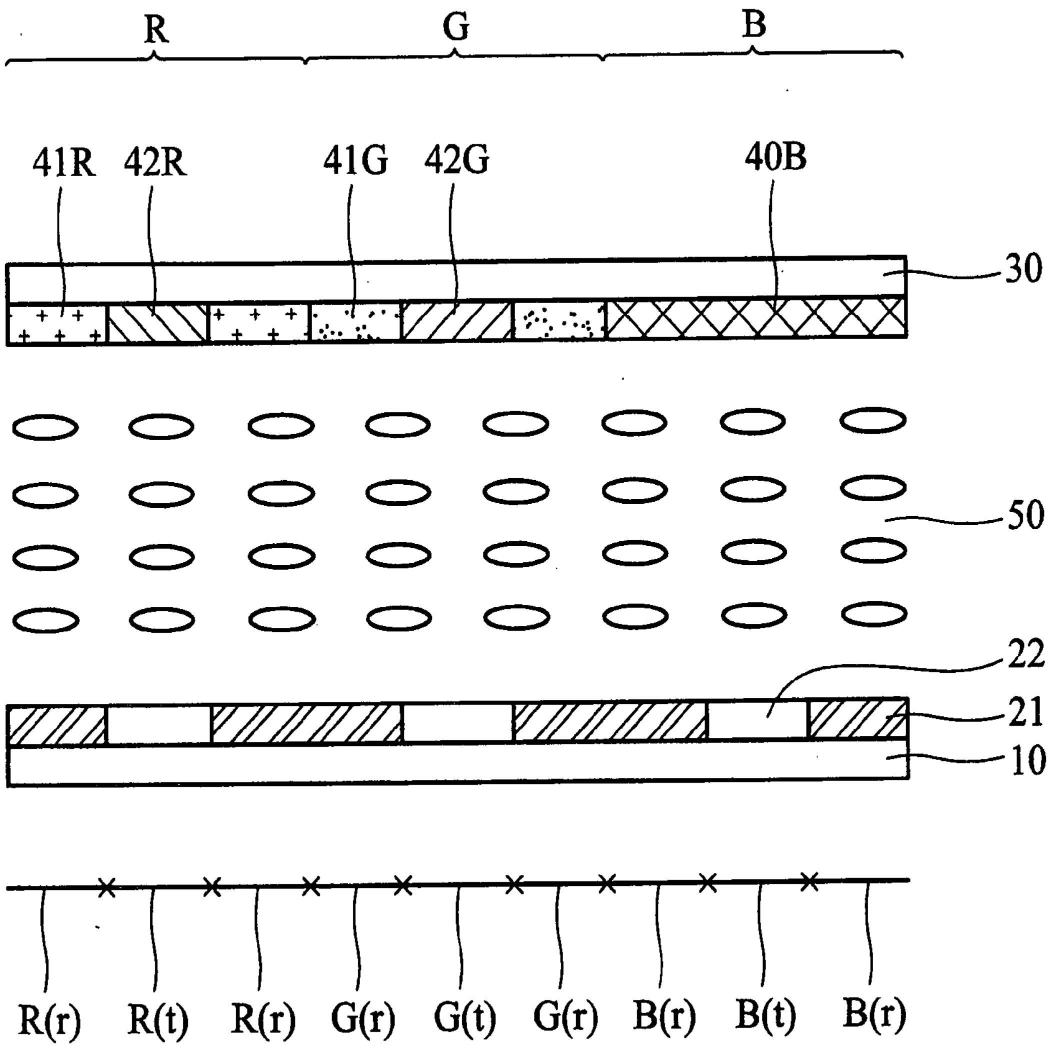
(57) ABSTRACT

A color filter including red, green, and blue resists in three subpixel regions in each pixel region is disclosed. One pixel region includes two kinds of color resists, and the color resist in the reflective region has lower purity than the color resist in the transmissive region. Another pixel region includes only one kind of color resist.



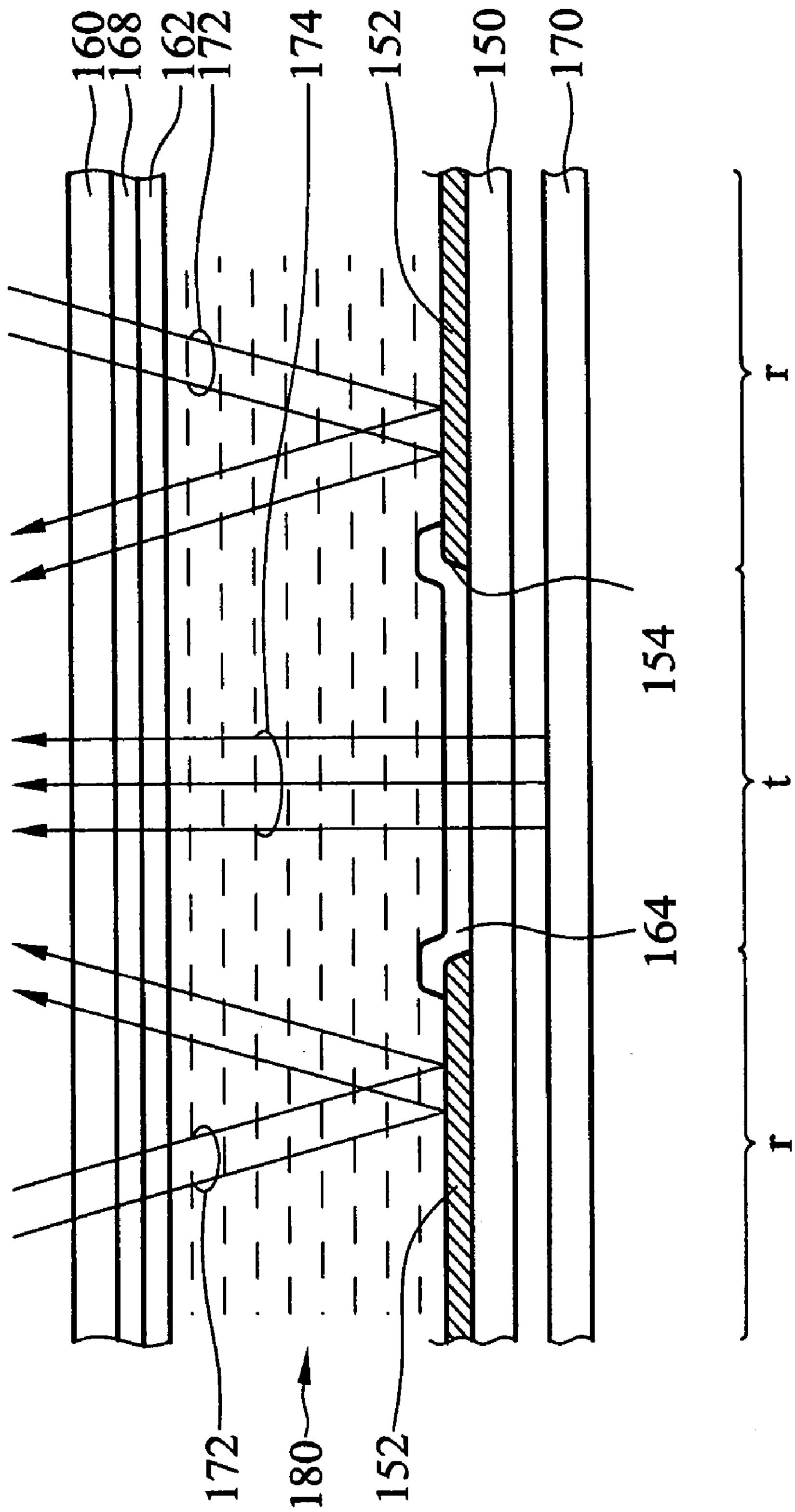


FIG. 1 (RELATED ART)

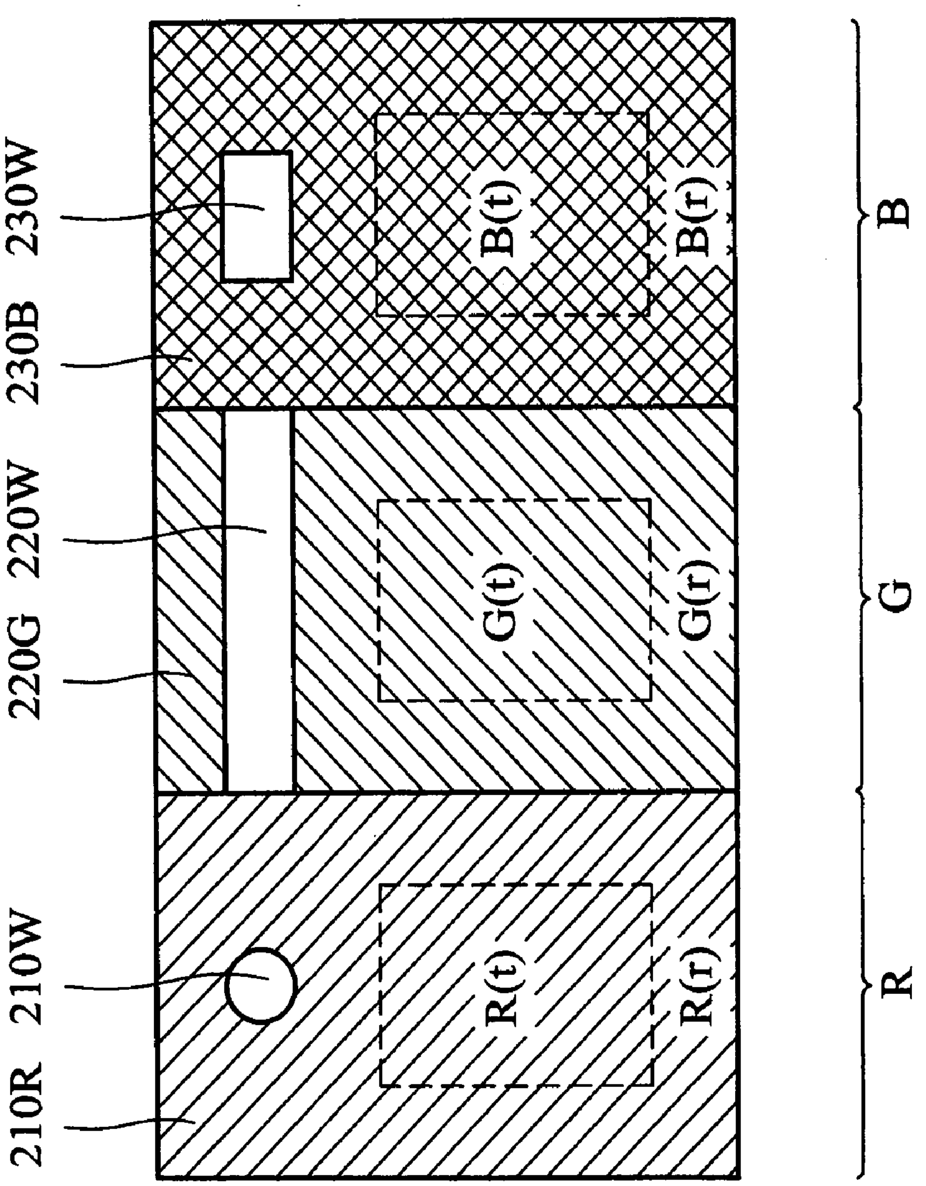


FIG. 2 (RELATED ART)

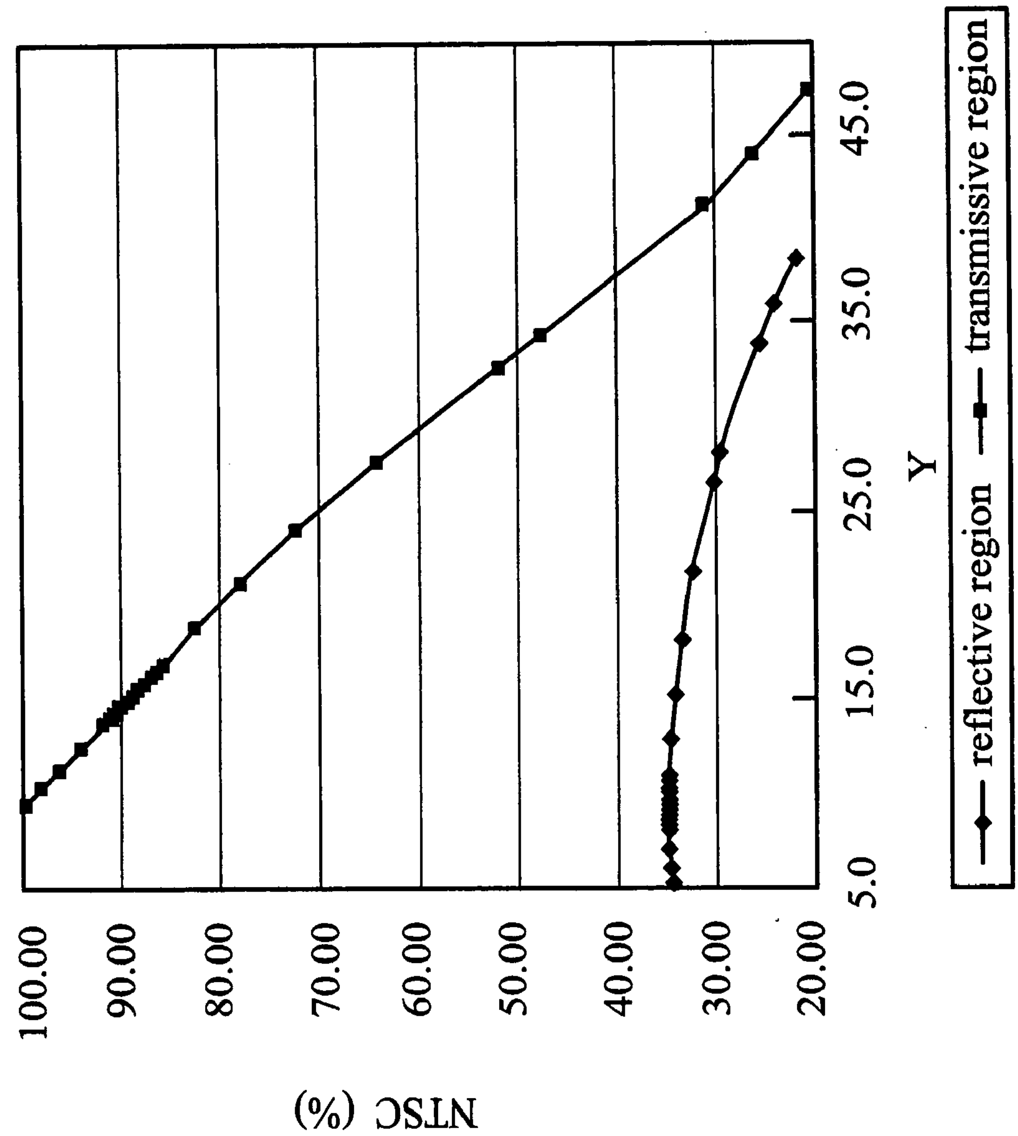


FIG. 3 (RELATED ART)

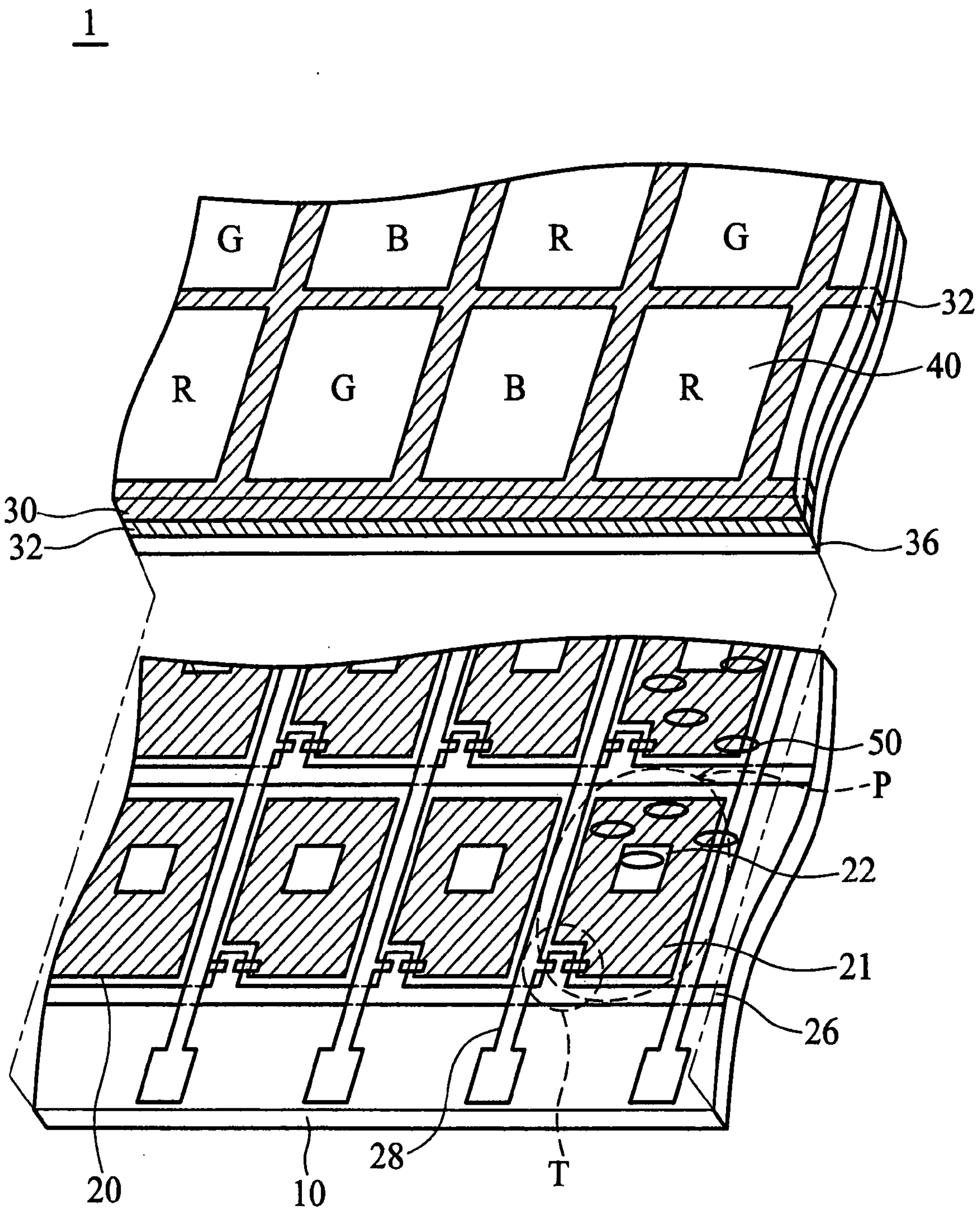


FIG. 4

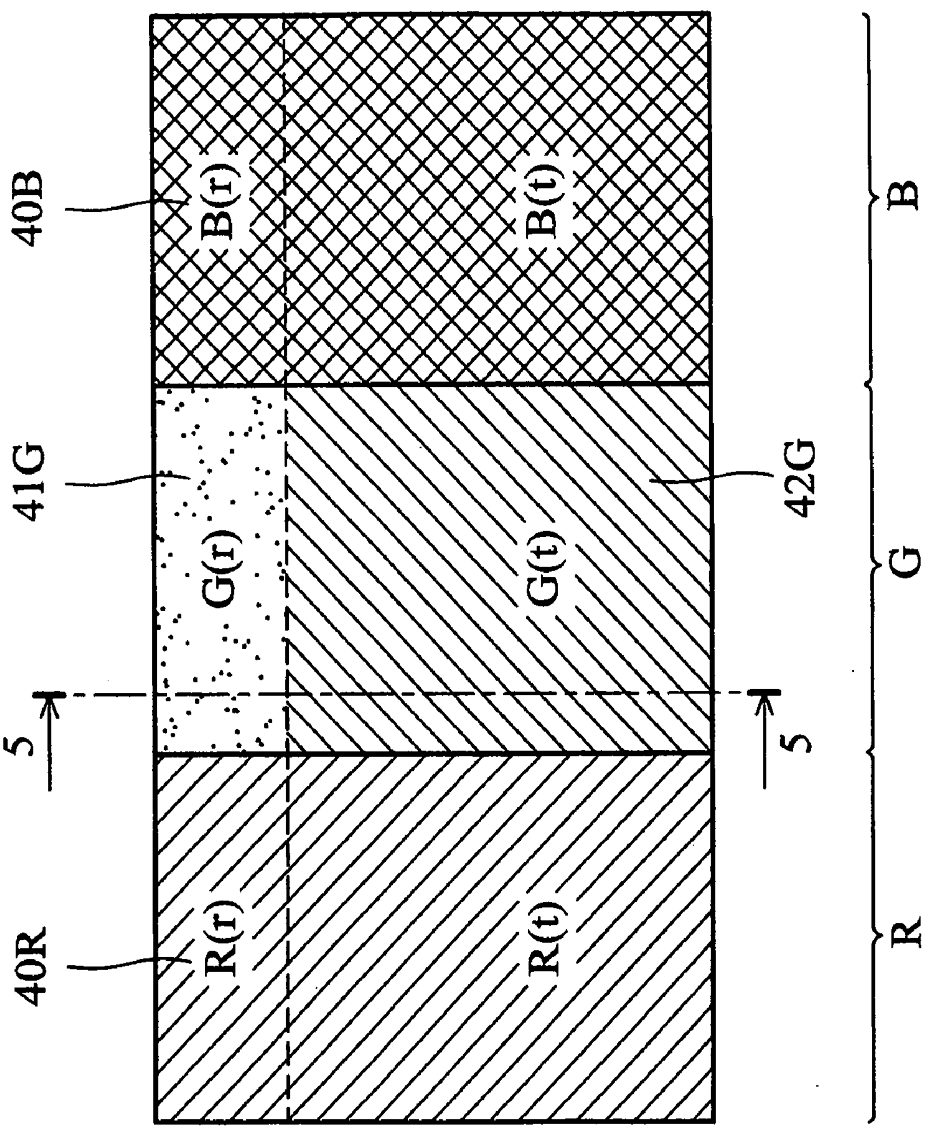


FIG. 5

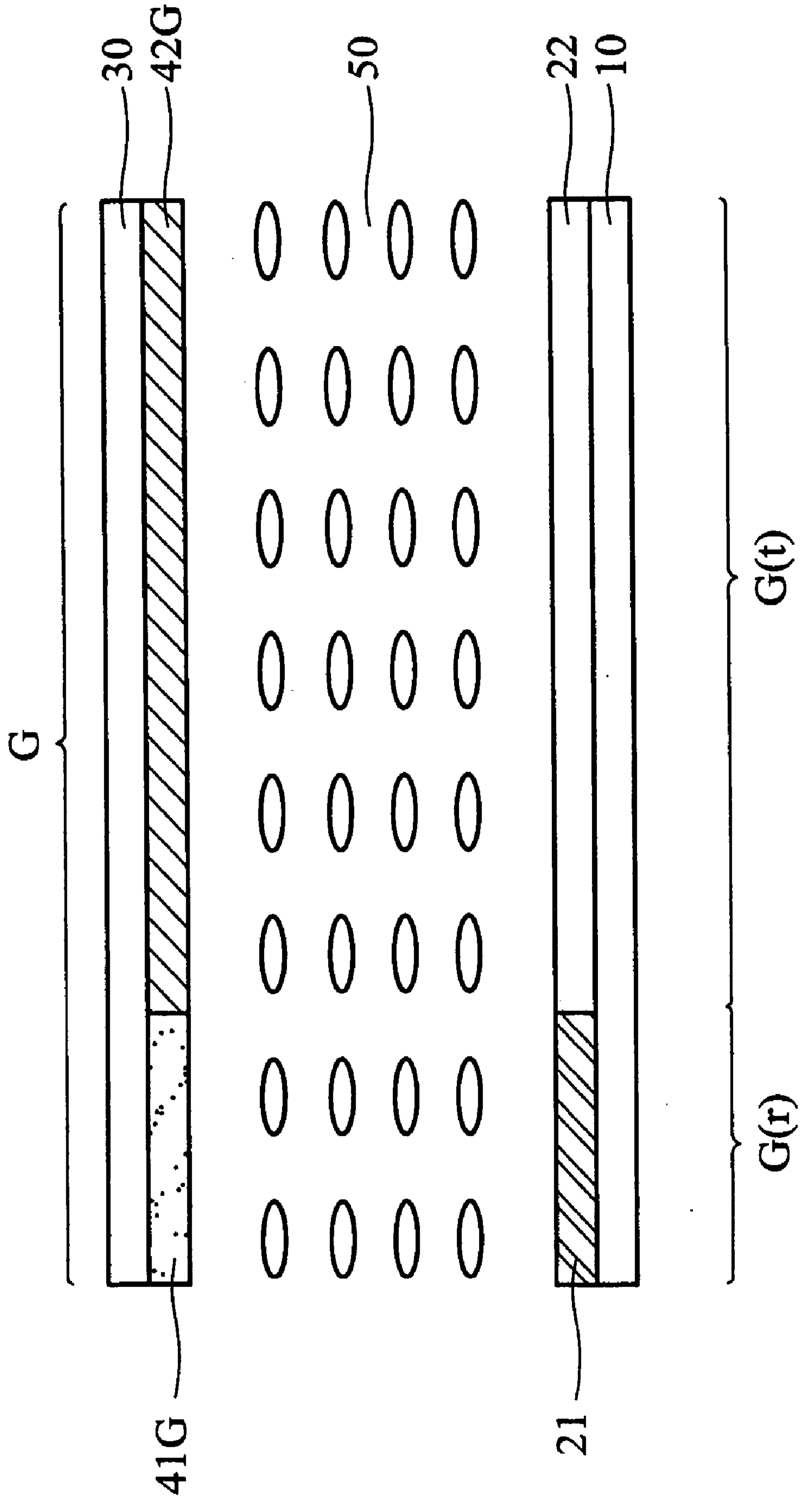


FIG. 6

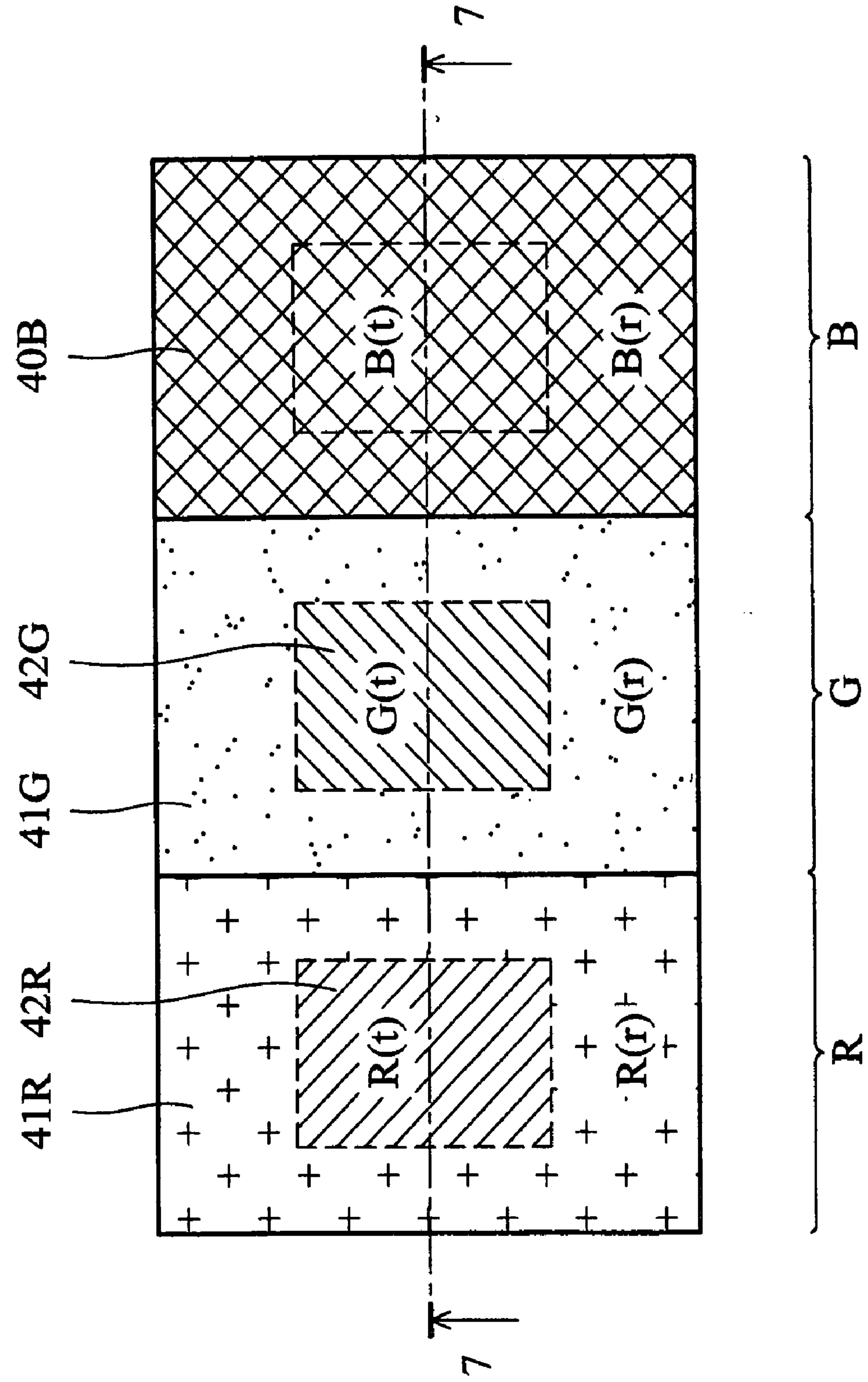


FIG. 7

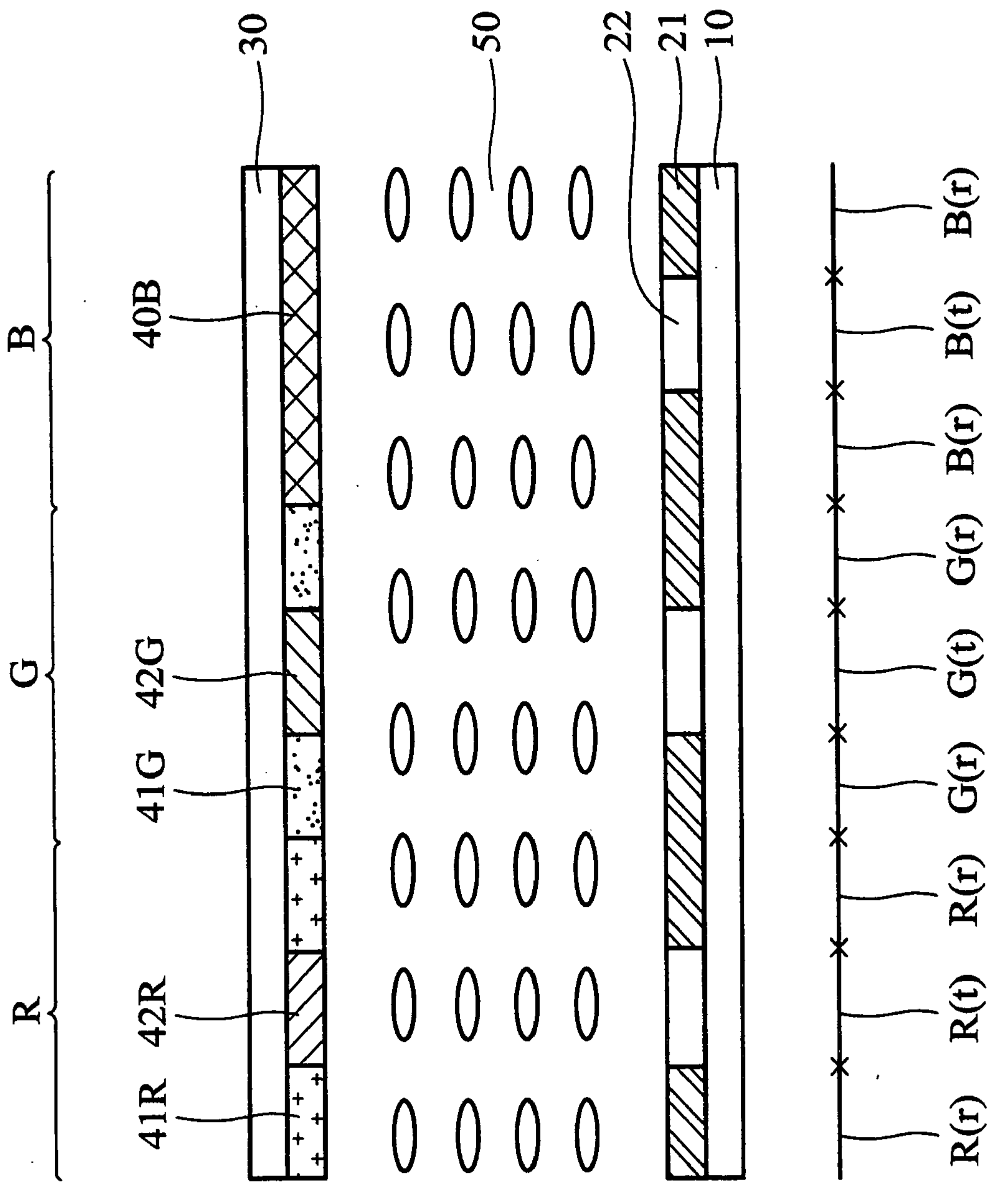


FIG. 8

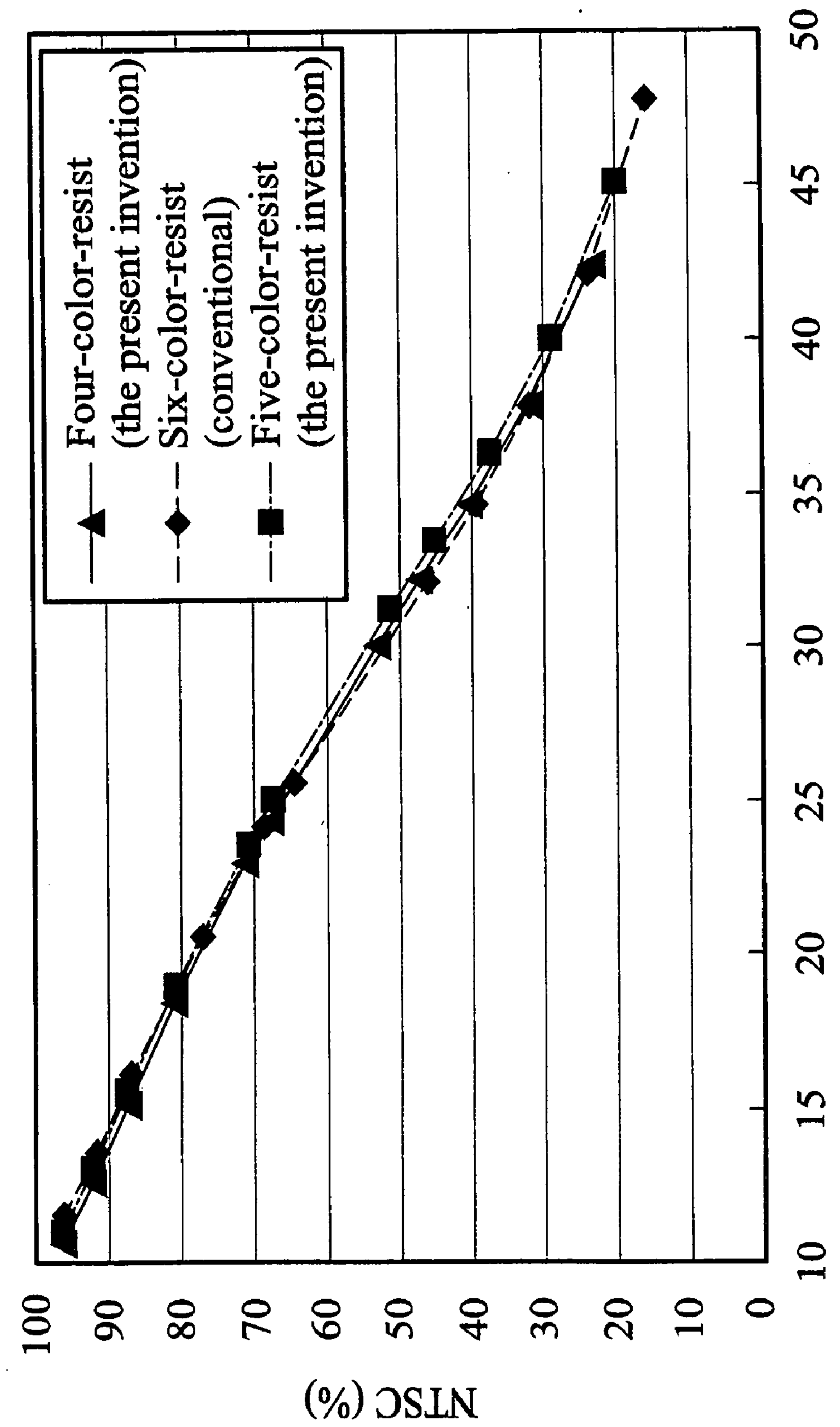

Four-color-resist
(the present invention)
Six-color-resist
(conventional)
Five-color-resist
(the present invention)
NTSC (%)
Y
0
10
20
30
40
50
60
70
80
90
100
10
15
20
25
30
35
40
45
50

FIG. 9

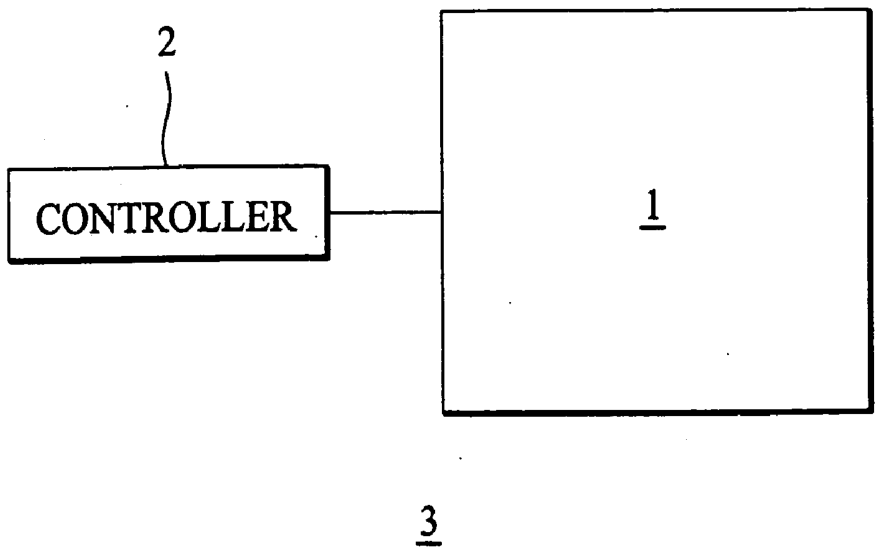


FIG. 10

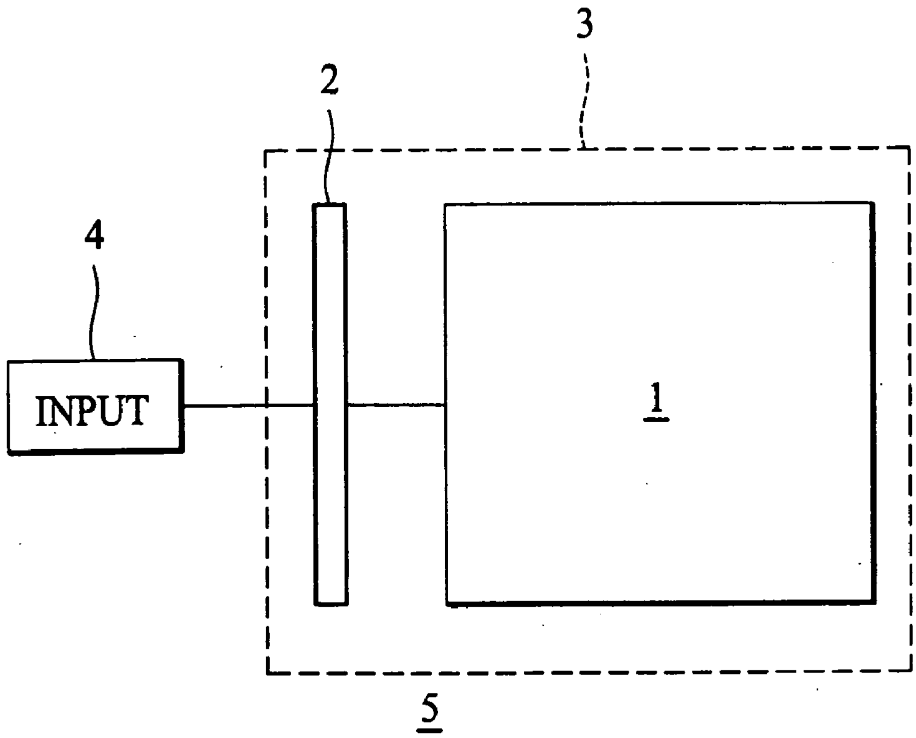


FIG. 11

TRANSFLECTIVE LIQUID CRYSTAL DISPLAY AND COLOR FILTER FOR THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a color filter, and more particularly to a color filter for a transflective liquid crystal display.

[0003] 2. Description of the Related Art

[0004] Liquid crystal displays (LCDs) are divided into three types: transmissive LCDs, reflective LCDs, and transflective LCDs. The transmissive LCD displays show images using light from a back light device. Only about 10% of light generated by the back light is utilized after passing through polarizers and LCD panel. Therefore, the transmissive LCD employs a backlight device capable of high brightness, requiring high power consumption. The reflective LCD uses ambient light to display images, thus reducing power consumption. The reflective LCD, however, can only be used during the day or in an office where external light is present, but not under dim lighting conditions.

[0005] Therefore, transflective LCDs have been introduced. **FIG. 1** is a cross-section of a conventional transflective liquid crystal display. The transflective LCD includes opposing upper and lower substrates **160** and **150**, a liquid crystal layer **180** interposed therebetween, and a backlight **170** under the lower substrate **150**. A common electrode **162** is formed between the upper substrate **160** and the liquid crystal layer **180**. A transmissive electrode **164** is formed in the transmissive region t of the lower substrate **150**. A reflective electrode **152** is formed in the reflective region r of the lower substrate **150**. A color filter layer **168** is interposed between the upper substrate **160** and common electrode **162**. In transmissive mode, light **174** emitted from the backlight **170** passes through the lower substrate **150**, the transmissive electrode **164**, the color filter layer **168**, and the upper substrate **160**. In reflective mode, ambient light **172** passes through the upper substrate **160** and color filter layer **168**, is incident to the reflective electrode **152**, is reflected by the reflective electrode **152**, and passes through the color filter layer **168** and the upper substrate **160** again.

[0006] As mentioned above, in the transmissive region t, light **174** emitted from the backlight **170** passes through the color filter layer **168** only once. In the reflective region r, however, ambient light **172** passes through the color filter **168** twice. Consequently, the color saturation in the reflective region will be higher than that in the transmissive region.

[0007] In order to solve the above problem, Tomohisa Matsushita et al. in U.S. Pat. No. 6,501,521 disclose forming a hole or slit in the color resist in the reflective region and then filling a transparent material therein, thus changing the color saturation in the reflective region. For example, **FIG. 2** is a top view of color resists in a pixel region of a transflective liquid crystal display. The pixel includes R (red), G (green), and B (blue) subpixel regions. Each subpixel region includes reflective and transmissive regions. The reflective regions are labeled R(r), G(r) and B(r), the transmissive regions are labeled R(t), G(t) and B(t), and the color resists are labeled **210**R, **220**G, and **230**B. The red resist **210**R in the reflective region R(r) in the R subpixel region is partially removed and then filled with a transparent material **210**W. The green resist **220**G in the reflective region G(r) in the G subpixel region is partially removed and then filled with a transparent material **220**W. The blue resist **230**B in the reflective region B(r) in the B subpixel region is partially removed and then filled with a transparent material **230**W. Color mixing of the transparent and color resists in the reflective region can be controlled by adjusting the size of the opening, in order to decrease the color saturation in the reflective region. Thus, the color saturation in the reflective and transmissive regions becomes substantially equal.

[0008] The above method can decrease the color saturation in the reflective region. However, referring to **FIG. 3**, the color saturation (NTSC(%)) in the reflective region is limited when brightness is low ($Y<15.0$) and differs greatly from the color saturation in the transmissive region.

[0009] A resist direct electrodeposition method is used so as to produce a color filter with different color purity between the transmission regions and the reflection regions. With this method, color filter portions with different color purity are formed in the transmission regions and in the reflection regions for each color. In this way, it is possible to increase the color saturation in a transmission mode while maintaining the brightness in a reflection mode. However, forming color filter portions of different transmittances in the transmission regions and in the reflection regions increases the number of steps in the color filter electrodeposition process. Specifically, electrodepositing reflection color filter portions and transmission color filter portions for each of R, G and B requires a total of six photolithography steps. Moreover, it requires two color filter materials of different color purity for each color. Thus, the production cost increases.

SUMMARY OF THE INVENTION

[0010] The present invention provides improvements over the prior art color filter configurations for transflective liquid crystal displays, including simplifying the color filter structure by limiting color saturation compensation at the reflective region of the color that is most sensitive to a viewer under anticipated ambient lighting conditions (e.g., halogen light, incandescent light, . . . etc.), to offset non-uniformity in color saturation between the reflective and transmissive regions for the color. In one aspect, the present invention compensates for the increase in color saturation in the reflective region by providing a color filter material that has a reduced color purity compared to that at the transmissive region. The color saturation between the reflective region and the transmissive region of the color subpixel region being compensated can be balanced (e.g., to make more uniform or to achieve a desired overall color saturation in reference to the other two color subpixel regions) by taking into consideration one or more of the following factors: the relative area of the reduced color purity area over the reflective electrode, the relative color purity between the reflective region and the transmissive region, the effect or relationship of the color purity level and the area of the reduced color purity area at the reflective region, how the other color subpixel regions (e.g., size, color, intensitity, etc.) may affect the size and/or color purity level at the reflective region of the color subpixel region that is being compensated in order to obtain the overall color saturation effect, choice of color subpixel region being compensated, relative sizes of the three color subpixel regions.

[0011] The present invention also provides a transflective liquid crystal display panel including the above color filter.

[0012] The present invention also provides a transflective liquid crystal display device including the above color filter.

[0013] The color filter of the present invention includes a plurality of pixel regions, each pixel region includes three subpixel regions, and each subpixel region includes a transmissive region and a reflective region. The color filter in each pixel region includes three color resists of different color, that is, R (red), G (green) and B (blue). The feature of the present invention resides in that one subpixel region includes two kinds of color resists and the color resist in the reflective region has lower color purity than the color resist in the transmissive region, while another subpixel region includes only one kind of color resist.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings, given by way of illustration only and thus not intended to be limitative of the present invention.

[0015] **FIG. 1** is a cross-sectional view of a conventional transflective LCD.

[0016] **FIG. 2** is a top view of color resists in a pixel region of another conventional transflective LCD.

[0017] **FIG. 3** shows the relationship between the color saturation and Y of a conventional color filter.

[0018] **FIG. 4** is an exploded perspective view illustrating a transflective LCD panel according to embodiments of the invention.

[0019] **FIG. 5** is a top view of the color filter in a pixel unit according to a first embodiment of the present invention.

[0020] **FIG. 6** shows a transflective liquid crystal display panel, which is a cross-section taken along line **5-5** of **FIG. 5**.

[0021] **FIG. 7** is a top view of the color filter in a pixel unit according to a second embodiment of the present invention.

[0022] **FIG. 8** is a cross-sectional view of a transflective LCD panel taken along line **7-7** of **FIG. 7**.

[0023] **FIG. 9** shows the relationship between the color saturation and Y of the four-color-resist (the present invention), five-color-resist (the present invention), and six-color-resist (conventional) color filters.

[0024] **FIG. 10** is a schematic diagram of a transflective LCD device incorporating the color filter configuration in accordance with the present invention.

[0025] **FIG. 11** is a schematic diagram of an electronic device having a transflective LCD device incorporating the color filter configuration in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0026] The following description is of the best-contemplated mode of carrying out the invention. This description is made for the purpose of illustrating the general principles of the invention and should not be taken in a limiting sense. The scope of the invention is best determined by reference to the appended claims.

[0027] It is noted that the description hereinbelow refers to various layers arranged on, above or overlying other layers, to describe the relative positions of the various layers. References to "on", "above", "overlying", or other similar languages, are not limited to the interpretation of one layer being immediately adjacent another layer. There may be intermediate or interposing layers, coatings, or other structures present, and associated process steps present, which are not shown or discussed herein, but could be included without departing from the scope and spirit of the invention disclosed herein. Similarly, references to structures adjacent, between or other positional references to other structures merely describe the relative positions of the structures, with or without intermediate structures.

[0028] **FIG. 4** is an exploded perspective view illustrating a transflective LCD panel **1** according to embodiments of the invention. The transflective LCD panel **1** includes upper and lower substrates **30** and **10** with a liquid crystal layer **50** interposed therebetween. The upper substrate **30** is a color filter substrate and the lower substrate **10** is an array substrate. In the upper substrate **30**, on a surface opposing the lower substrate **10**, a black matrix **32** and a color filter layer **40** including a plurality of red (R), green (G) and blue (B) color filters are formed. That is, the black matrix **32** surrounds each color filter, in the shape of an array matrix. Further on the upper substrate **30**, a common electrode **36** is formed to cover the color filter layer **40** and the black matrix **32**.

[0029] In the lower substrate **10**, on a surface opposing the upper substrate **30**, a plurality of TFTs "T" serving as switching devices are formed in shape of an array matrix corresponding to the color filters **40**. In addition, a plurality of crossing gate and data lines **26** and **28** are positioned such that each TFT is located near each cross point of the gate and data lines **26** and **28**. Further on the lower substrate **10**, a plurality of pixel regions (P) are defined by the gate and data lines **26** and **28**. Each pixel region P has a pixel electrode **20** comprising a transparent portion **22** and an opaque portion **21**. The transparent portion **22** comprises a transparent conductive material, such as ITO (indium tin oxide) or IZO (indium zinc oxide), and the opaque portion **22** comprises a metal having high reflectivity, such as Al (aluminum).

[0030] According to the present invention, one subpixel region includes different kinds of color resists in reflective and transmissive regions respectively, while another subpixel region includes only one kind of color resist. The color resist in the reflective region has lower color purity, and the color resist in the transmissive region has higher color purity. In this way, color saturation in the entire reflective region is reduced, thus allowing the desired color saturation distribution between the reflective region and the transmissive region to be balanced, such as to make the color saturation in reflective and transmissive regions to be substantially equal.

[0031] **FIG. 5** is a top view of the color filter in a pixel unit according to a first embodiment of the present invention. The pixel unit includes three subpixel regions: R, G, and B. It shows that two green resists of different color purity are used in the green subpixel region. Corresponding to the reflective and transmissive regions of the array substrate (**FIG. 5** shows a portion of the array substrate **10**), each subpixel region of the color filter includes reflective and transmissive regions, that is, a red reflective region R(r), a green reflective region G(r), a blue reflective region B(r), a red transmissive region R(t), a green transmissive region G(t), and a blue transmissive region B(t). **FIG. 5** shows that in the subpixel region, the reflective region is adjacent to the transmissive region. However, the invention is not limited to this. The reflective region in the subpixel region can also surround the transmissive region (see **FIG. 7**).

[0032] Referring to **FIG. 5**, the R subpixel region uses one kind of red resist **40**R, and the B subpixel region uses one kind of blue resist **40**B. However, the G subpixel region uses two green resists: a first green resist **41**G disposed in the green reflective region G(r), and a second green resist **42**G disposed in the green transmissive region G(t). The first green resist **41**G has lower color purity than the second green resist **42**G.

[0033] **FIG. 6** is a cross-section of a subpixel of the transflective LCD panel **1** taken along line **5-5** of **FIG. 5**, showing the G subpixel region. Referring to **FIG. 6**, the transflective LCD panel **1** includes a first substrate **10**, a second substrate **30**, and a liquid crystal layer **50** interposed therebetween. The G subpixel region includes a first green resist **41**G corresponding to a reflective electrode **21**, and a second green resist **42**G corresponding to a transmissive electrode **22**. Since the first green resist **41**G in the reflective region G(r) has lower color purity than the second green resist **42**G in the transmissive region G(t), the color saturation in the entire reflective region is reduced, thus the color saturation in the entire reflective and transmissive regions becomes substantially equal. The color filter of the present invention can be produced on either the first substrate **10** or the second substrate **30**. Put simply, the color filter of the first embodiment includes one kind of red resist **40**R, one kind of blue resist **40**B, and two kinds of green resists **41**G and **42**G. Additionally, the green resist **41**G in the reflective region has lower color purity than the green resist **42**G in the transmissive region.

[0034] **FIG. 7** is a top view of the color filter in a pixel unit according to a second embodiment of the present invention, showing that two color resists of different color purity are used in green and red subpixel regions respectively. The pixel unit includes three subpixel regions: R, G, and B, and each subpixel region includes reflective and transmissive regions, that is, a red reflective region R(r), a green reflective region G(r), a blue reflective region B(r), a red transmissive region R(t), a green transmissive region G(t), and a blue transmissive region B(t).

[0035] The B subpixel region uses one kind of blue resist **40**B. The G subpixel region uses two kinds of green resists: a first green resist **41**G disposed in the green reflective region G(r), and a second green resist **42**G disposed in the green transmissive region G(t), wherein the first green resist **41**G has lower color purity than the second green resist **42**G. The R subpixel region uses two kinds of red resists: a first red resist **41**R disposed in the red reflective region R(r), and a second red resist **42**B disposed in the red transmissive region R(t), wherein the first red resist portion **41**R has lower color purity than the second red resist portion **42**R. In **FIG. 7**, the reflective region in the subpixel region surrounds the transmissive region.

[0036] **FIG. 8** is a cross-section of a transflective LCD panel taken along line **7-7** of **FIG. 7**. Referring to **FIG. 8**, the transflective LCD panel includes a first substrate **10**, a second substrate **30**, and a liquid crystal layer **50** interposed therebetween. The G subpixel region includes a first green resist **41**G corresponding to a reflective electrode **21**, and a second green resist **42**G corresponding to a transmissive region **22**. The R subpixel region includes a first red resist **41**R corresponding to a reflective electrode **21**, and a second red resist **42**R corresponding to a transmissive region **22**.

[0037] Since the first green resist portion **41**G in the reflective region G(R) has lower color purity than the second green resist portion **42**G in the transmissive region G(t), and the first red resist portion **41**R in the reflective region R(r) has lower color purity than the second red resist portion **42**R in the transmissive region R(t), the color saturation in the entire reflective region is reduced, thus the color saturation in the entire reflective and transmissive regions becomes substantially equal. The color filter of the present invention can be produced on either the first substrate **10** or the second substrate **30**.

[0038] **FIG. 10** is a schematic diagram illustrating a liquid crystal display device incorporating the transflective liquid crystal display panel **1** of **FIG. 4** manufactured according to the first embodiment of the present invention. The LCD panel **1** as shown in **FIG. 4** is coupled to a controller **2** to form a LCD device **3**. The controller **2** can comprise a source and gate driving circuits (not shown) to control the LCD panel **1** to render image in accordance with an input.

[0039] **FIG. 11** is a schematic diagram illustrating an electronic device incorporating the LCD device **3** shown in **FIG. 10**. An input device **4** is coupled to the controller **2** of the LCD device **3** to form an electronic device **5**. The input device **4** can include a processor or the like to input data to the controller **2** to render an image. The electronic device **5** may be a portable device such as a PDA, notebook computer, tablet computer, cellular phone, or a display monitor device, or non-portable device such as a desktop computer.

[0040] Put simply, the color filter of the second embodiment includes one kind of blue resist **40**B; two kinds of green resists **41**G and **42**G, wherein the green resist **41**G in the reflective region has lower color purity than the green resist **42**G in the transmissive region; and two kinds of red resists **41**R and **42**R, wherein the red resist **41**R in the reflective region has lower color purity than the red resist **42**R in the transmissive region.

[0041] The transmissive electrode is defined as an electrode in the transmissive region, and the reflective electrode is defined as an electrode in the reflective region.

Computer Simulation

[0042] (1) The four-color-resist color filter of the present invention includes one kind of blue resist, one kind of red resist, and two kinds of green resists. The green resist in the reflective region has lower color purity than the green resist in the transmissive region.

[0043] (2) The five-color-resist color filter of the present invention includes one kind of blue resist, two kinds of red resists, and two kinds of green resists. The red resist in the reflective region has lower color purity than the red resist in the transmissive region. The green resist in the reflective region has lower color purity than the green resist in the transmissive region.

[0044] (3) A conventional six-color-resist color filter includes two kinds of red resists, two kinds of green resists, and two kinds of blue resists. Red, green, and blue resists in the reflective region have lower color purity than red, green, and blue resists in the transmissive region respectively.

[0045] The above three types of color filters were simulated in a computer. The relationship between color saturation (NTSC(%)) and brightness (Y) are shown in **FIG. 9**. It can be seen that the four-color-resist and five-color-resist color filters of the present invention still maintains similar color property to the conventional six-color-resist color filter. In conclusion, in the present invention, one subpixel region uses two kinds of color resists, and the color resist in the reflective region has lower color purity than the color resist in the transmissive region; while another subpixel region uses only one kind of color resist. Compared with the conventional six-color-resist color filter, the present invention reduces production procedures while still maintaining substantially equal color saturation in reflective and transmissive regions.

[0046] The foregoing description of the preferred embodiments of this invention has been presented for purposes of illustration and description. Obvious modifications or variations are possible in light of the above teaching. The embodiments chosen and described provide an excellent illustration of the principles of this invention and its practical application to thereby enable those skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the present invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.

What is claimed is:

1. A color filter including a plurality of pixel regions, each pixel region including a plurality of color resists of different colors, each corresponding to a different subpixel region, each subpixel region including a transmissive region and a reflective region,

wherein at least one subpixel region includes two kinds of color resists respectively in the transmissive and reflective regions, the color resist in the reflective region having lower color purity than the color resist in the transmissive region, and

at least another subpixel region includes only one kind of color resist.

2. The color filter as claimed in claim 1, wherein the plurality of color resists include a red resist, wherein the red resist includes a first red resist in the reflective region and a second red resist in the transmissive region, the first red resist having lower color purity than the second red resist.

3. The color filter as claimed in claim 1, wherein the plurality of color resists include a green resist, wherein the green resist includes a first green resist in the reflective region and a second green resist in the transmissive region, the first green resist having lower color purity than the second green resist.

4. The color filter as claimed in claim 1, wherein the plurality of color resists include a blue resist, wherein the blue resist includes a first blue resist in the reflective region and a second blue resist in the transmissive region, the first blue resist having lower color purity than the second blue resist.

5. The color filter as claimed in claim 1, wherein the plurality of color resists include a red resist, a green resist and a blue resist, and wherein

the red resist includes a first red resist in the reflective region and a second red resist in the transmissive region, the first red resist having lower color purity than the second red resist; and

the green resist includes a first green resist in the reflective region and a second green resist in the transmissive region, the first green resist having lower color purity than the second green resist.

6. The color filter as claimed in claim 1, wherein the plurality of color resists include a red resist, a green resist and a blue resist, and wherein

the red resist includes a first red resist in the reflective region and a second red resist in the transmissive region, the first red resist having lower color purity than the second red resist; and

the blue resist includes a first blue resist in the reflective region and a second blue resist in the transmissive region, the first blue resist having lower color purity than the blue green resist.

7. The color filter as claimed in claim 1, wherein the plurality of color resists include a red resist, a green resist and a blue resist, and wherein

the green resist includes a first green resist in the reflective region and a second green resist in the transmissive region, the first green resist having lower color purity than the second green resist; and

the blue resist includes a first blue resist in the reflective region and a second blue resist in the transmissive region, the first blue resist having lower color purity than the second blue resist.

8. A transflective liquid crystal display panel comprising:

a first substrate;

a second substrate opposing the first substrate;

a color filter as in claim 1;

a plurality of reflective electrodes supported on the second substrate at locations corresponding to the reflective regions of the subpixel regions; and

a plurality of transmissive electrodes supported on the second substrate at locations corresponding to the transmissive regions of the subpixel regions.

a liquid crystal layer interposed between the first and second substrates.

9. The transflective liquid crystal display panel as claimed in claim 8, wherein the plurality of color resists include a red resist, wherein the red resist includes a first red resist in the reflective region and a second red resist in the transmissive region, the first red resist having lower color purity than the second red resist.

10. The transflective liquid crystal display panel as claimed in claim 8, wherein the plurality of color resists include a green resist, wherein the green resist includes a first green resist in the reflective region and a second green resist in the transmissive region, the first green resist having lower color purity than the second green resist.

11. The transflective liquid crystal display panel as claimed in claim 8, wherein the plurality of color resists include a blue resist, wherein the blue resist includes a first blue resist in the reflective region and a second blue resist in the transmissive region, the first blue resist having lower color purity than the second blue resist.

12. The transflective liquid crystal display panel as claimed in claim 8, wherein the plurality of color resists include a red resist, a green resist and a blue resist, and wherein

the red resist includes a first red resist in the reflective region and a second red resist in the transmissive region, the first red resist having lower color purity than the second red resist; and

the green resist includes a first green resist in the reflective region and a second green resist in the transmissive region, the first green resist having lower color purity than the second green resist.

13. The transflective liquid crystal display panel as claimed in claim 8, wherein the plurality of color resists include a red resist, a green resist and a blue resist, and wherein

the red resist includes a first red resist in the reflective region and a second red resist in the transmissive region, the first red resist having lower color purity han the second red resist; and

the blue resist includes a first blue resist in the reflective region and a second blue resist in the transmissive region, the first blue resist having lower color purity than the blue green resist.

14. The transflective liquid crystal display panel as claimed in claim 8, wherein the plurality of color resists include a red resist, a green resist and a blue resist, and wherein

the green resist includes a first green resist in the reflective region and a second green resist in the transmissive region, the first green resist having lower color purity than the second green resist; and

the blue resist includes a first blue resist in the reflective region and a second blue resist in the transmissive region, the first blue resist having lower color purity than the second blue resist.

15. A transflective liquid crystal display device, comprising:

the transflective liquid crystal display panel as claimed in claim 8; and

a controller coupled to the transflective liquid crystal display panel to control the panel to render an image in accordance with an input.

16. An electronic device, comprising:

the transflective liquid crystal display device as claimed in claim 15; and

an input device coupled to the controller of the transflective liquid crystal display device to control the transflective liquid crystal display device to render an image.

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专利名称(译)	透射式液晶显示器和滤色器相同		
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摘要(译)

公开了在每个像素区域中的三个子像素区域中包括红色，绿色和蓝色抗蚀剂的滤色器。一个像素区域包括两种颜色抗蚀剂，并且反射区域中的颜色抗蚀剂具有比透射区域中的颜色抗蚀剂低的纯度。另一像素区域仅包括一种颜色抗蚀剂。