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Fan et al.

(54) **PLACEMENT OF SPACERS IN A LIQUID CRYSTAL DISPLAY PANEL**

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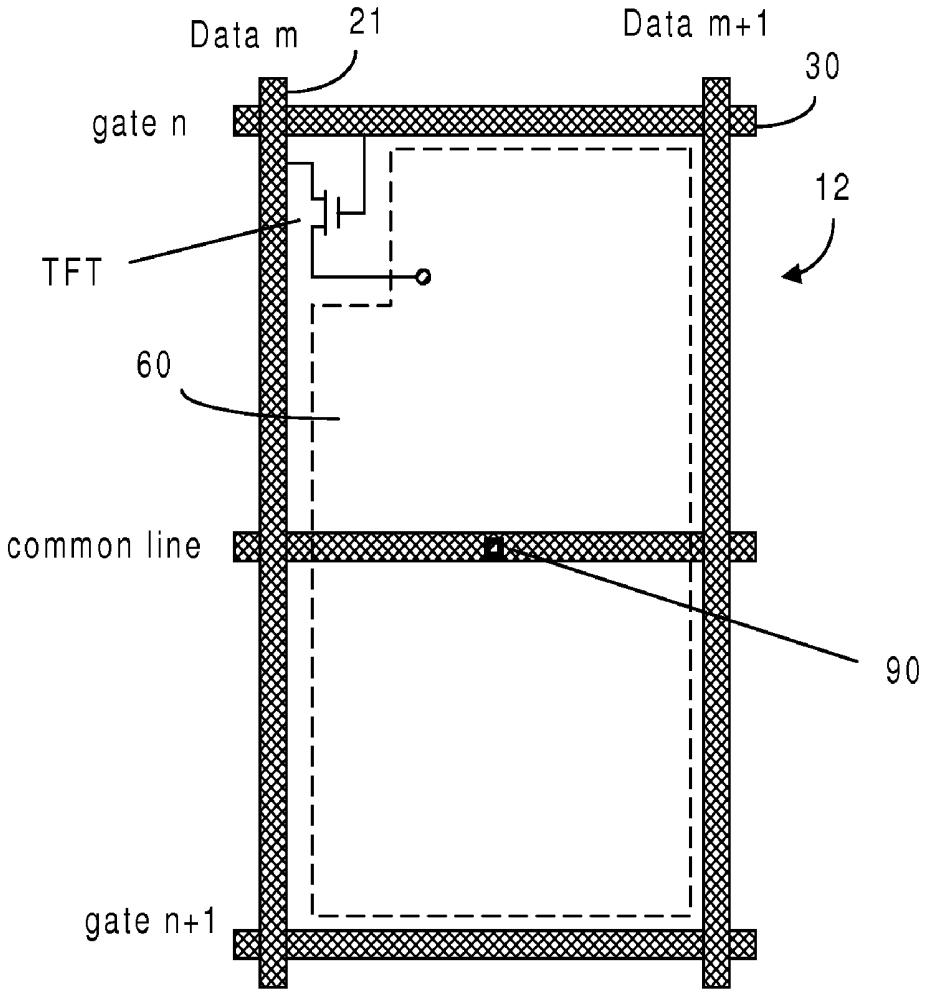
(52) **U.S. Cl.** **349/155**

(57) **ABSTRACT**

A plurality of spacers are used to control the gap in a liquid crystal display panel. When a spacer is associated with an electrode in the lower substrate where the switching elements and data lines are disposed, it is located substantially at the center of the electrode. In a transflective LCD sub-pixel, a spacer may be disposed at the center of one of the transmissive and reflective electrodes. Alternatively, a spacer is disposed at the center of each of the transmissive and reflective electrodes. When the electrode in a sub-pixel comprises different sections to affect the alignment of the liquid crystal layer associated with the electrode, the spacer is located at the intersection of the sections, if possible, so that the spacer is located at the intersections of different domains of the liquid crystal layer.



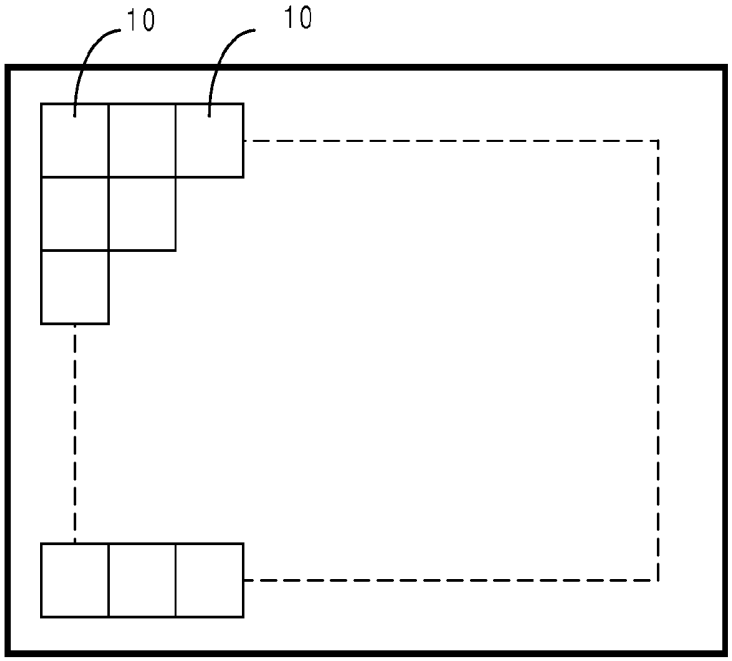


FIG. 1
(prior art)

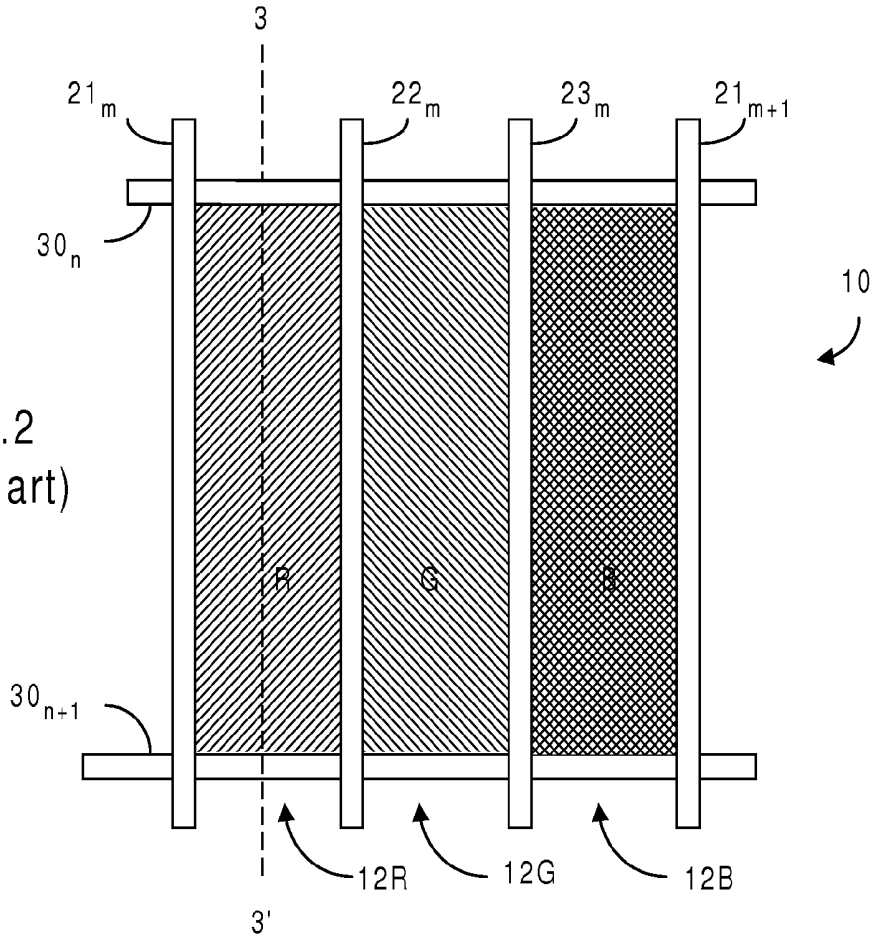


FIG.2
(prior art)

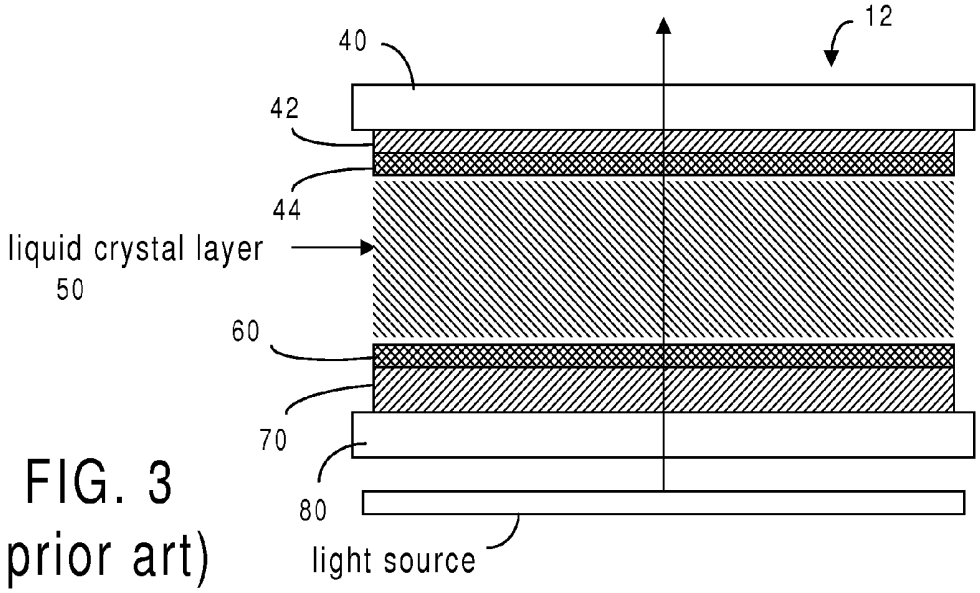


FIG. 3
(prior art)

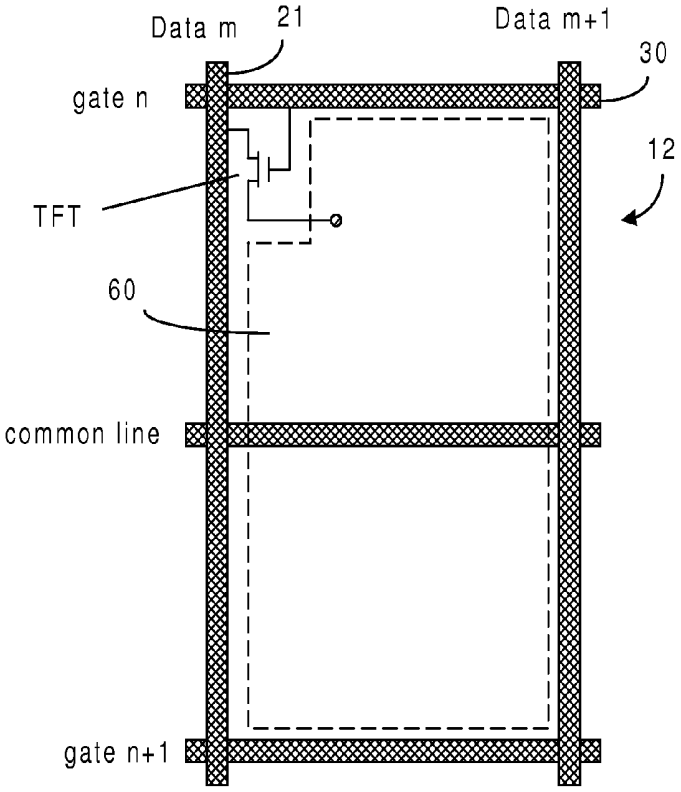


FIG. 4
(prior art)

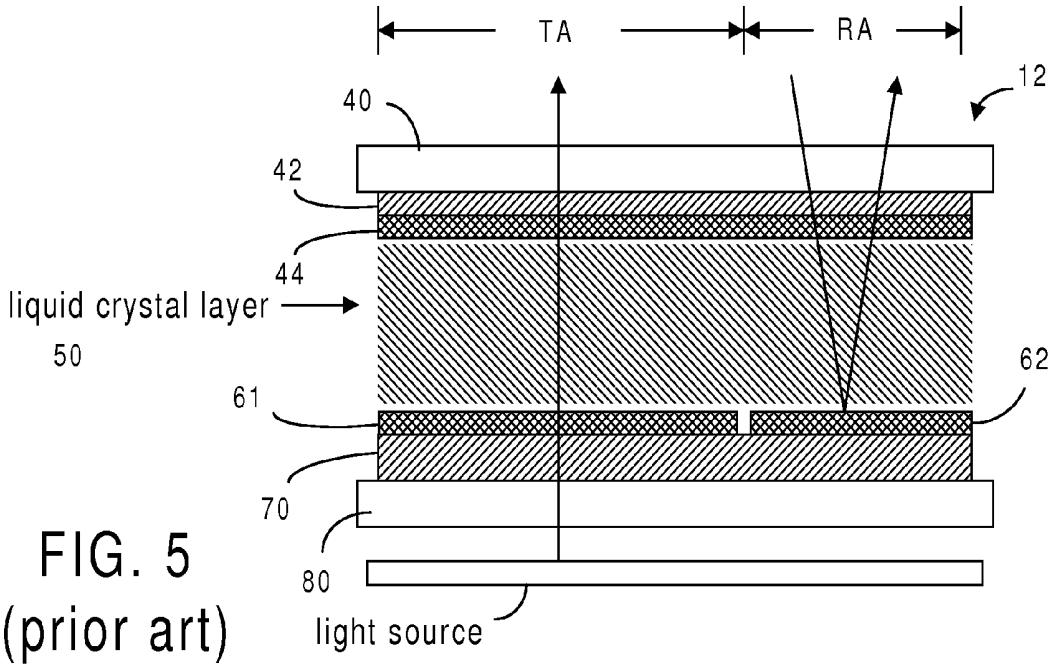


FIG. 5
(prior art)

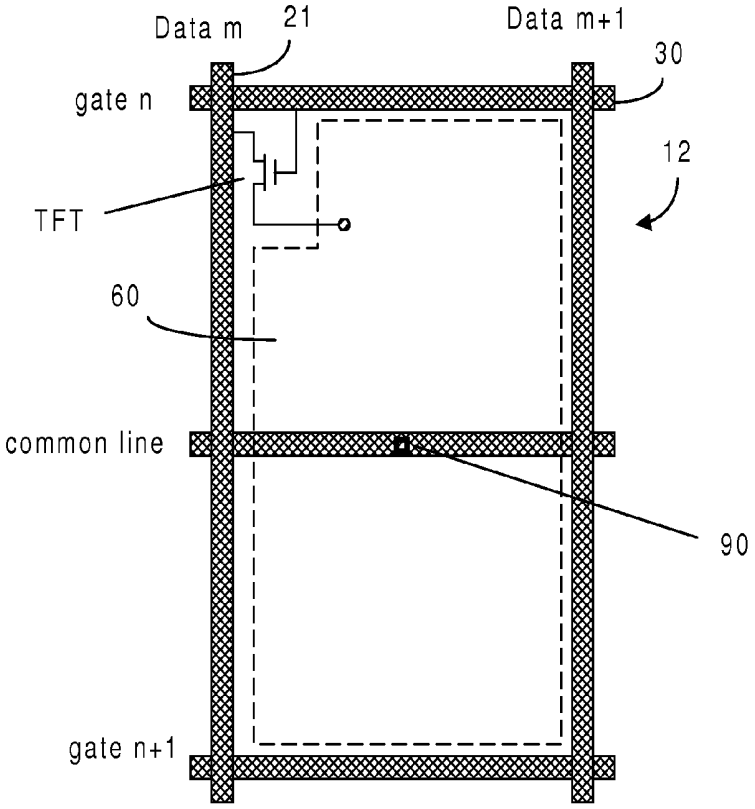


FIG. 6

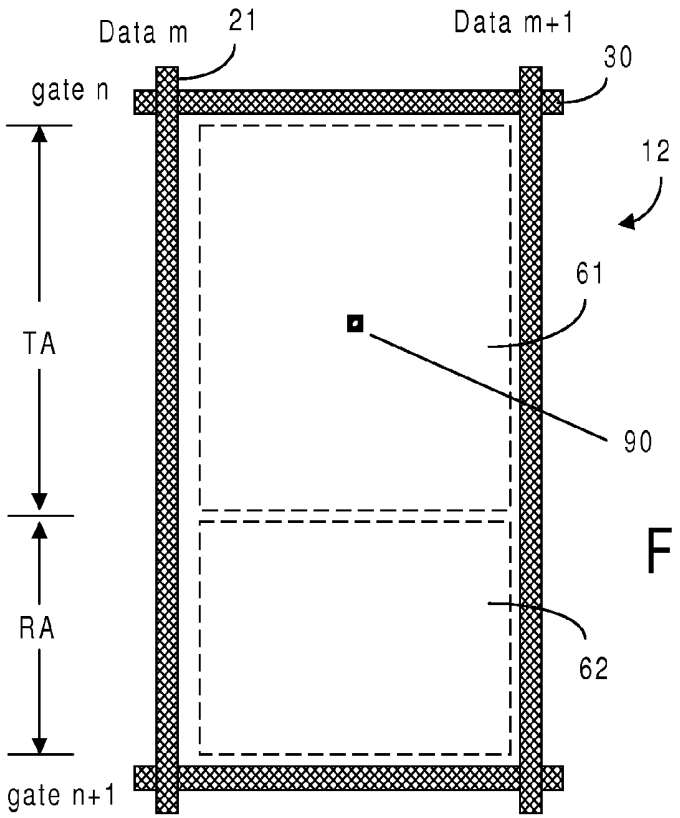

Data m
21
Data m+1
30
gate n
12
61
TA
90
RA
62
gate n+1

FIG. 7a

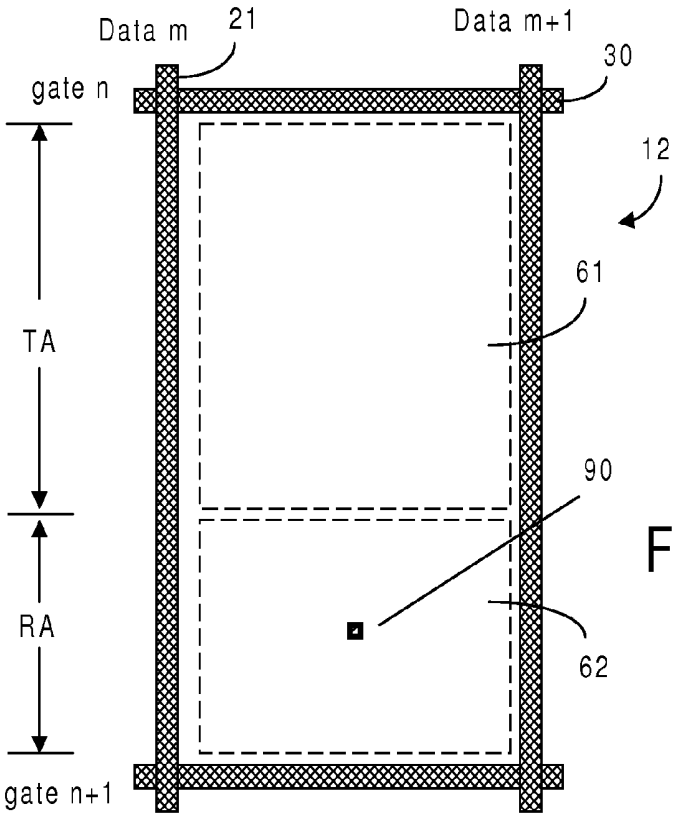

Data m
21
Data m+1
30
gate n
12
61
TA
90
RA
62
gate n+1

FIG. 7b

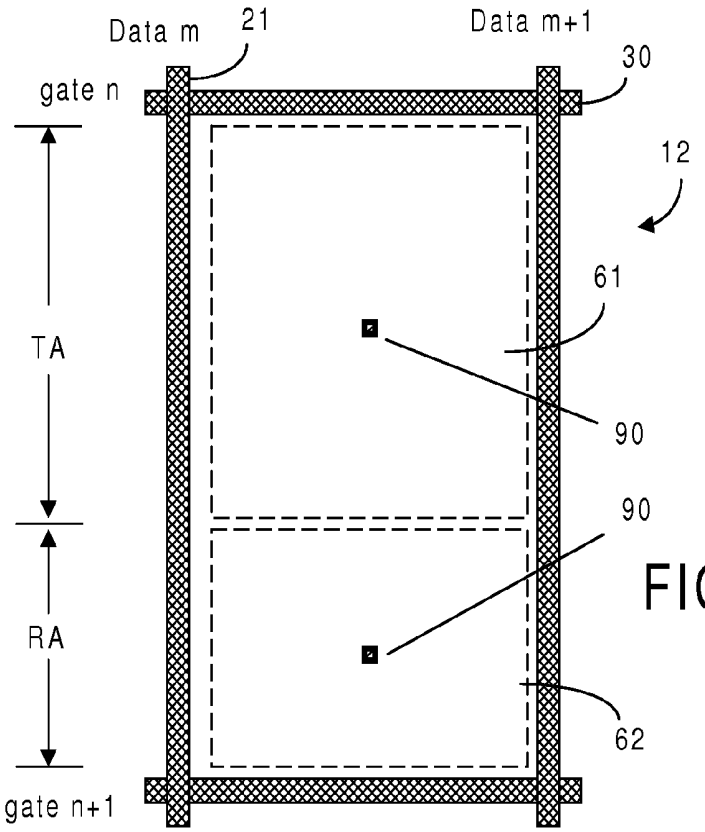

Data m
21
Data m+1
30
gate n
12
61
TA
90
90
RA
62
gate n+1

FIG. 7c

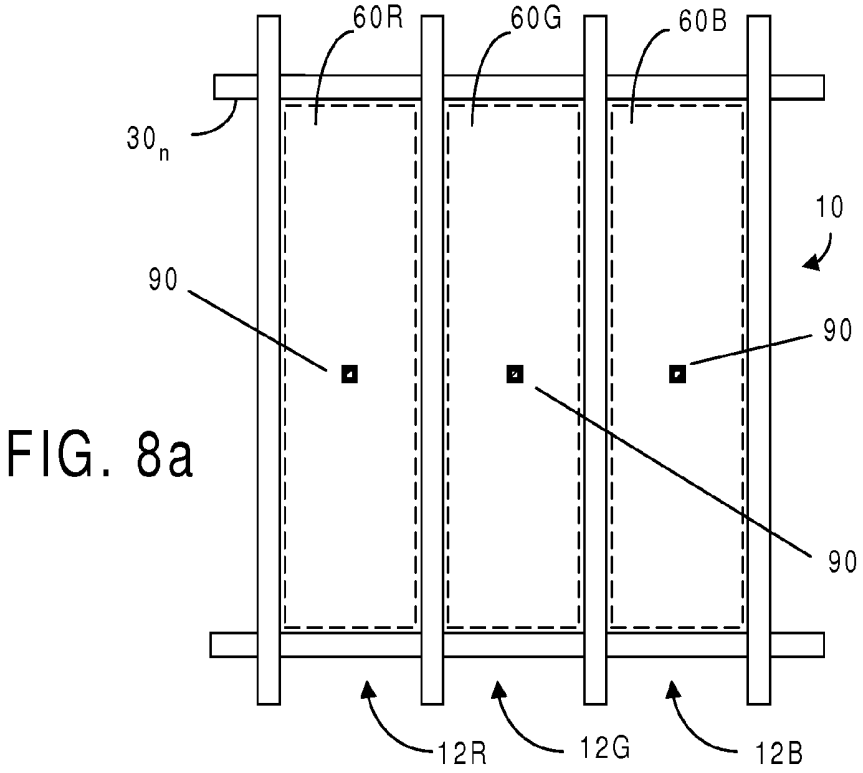

60R
60G
60B
30_n
10
90
90
90
12R
12G
12B

FIG. 8a

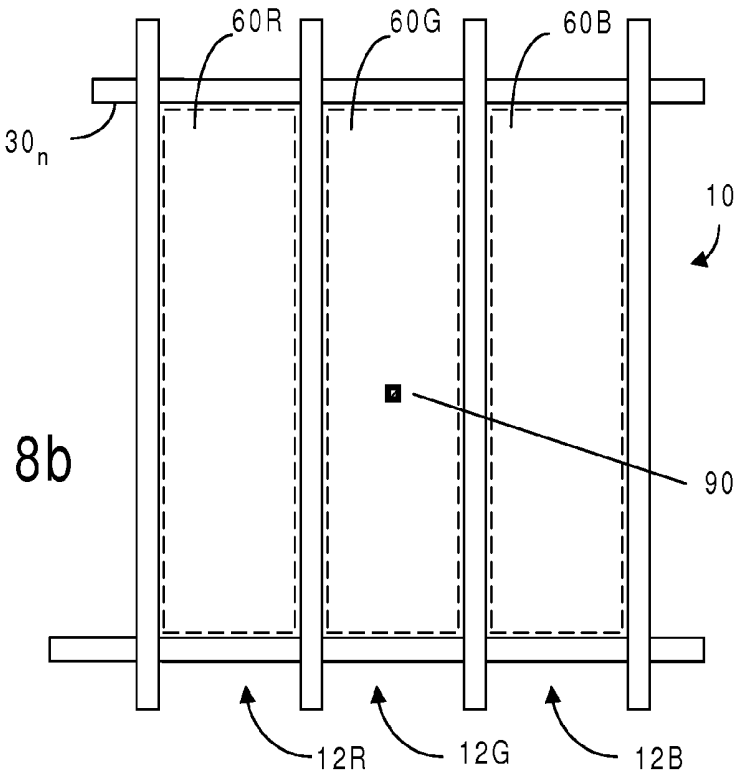

60R
60G
60B
30n
10
90
12R
12G
12B

FIG. 8b

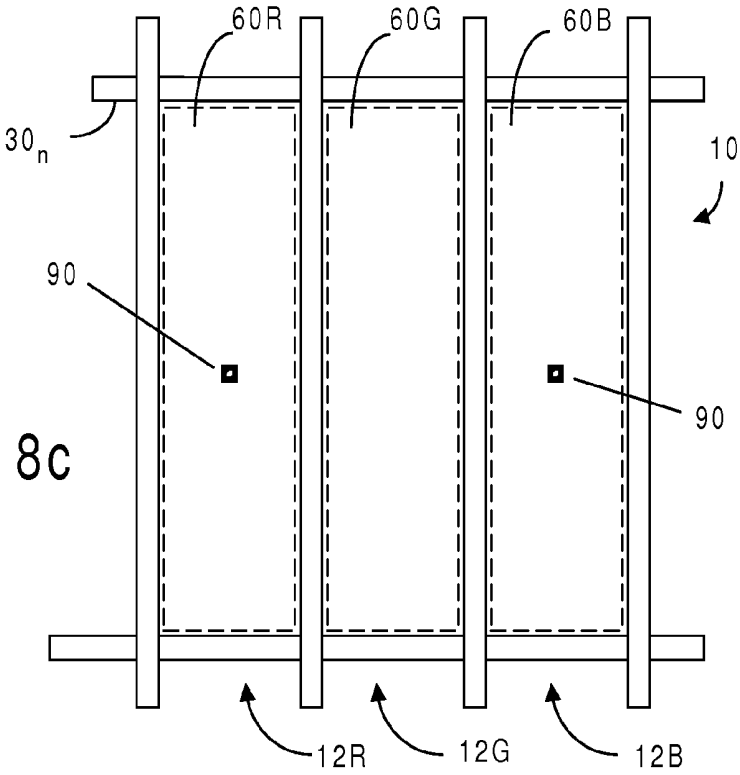

60R
60G
60B
30n
10
90
90
12R
12G
12B

FIG. 8c

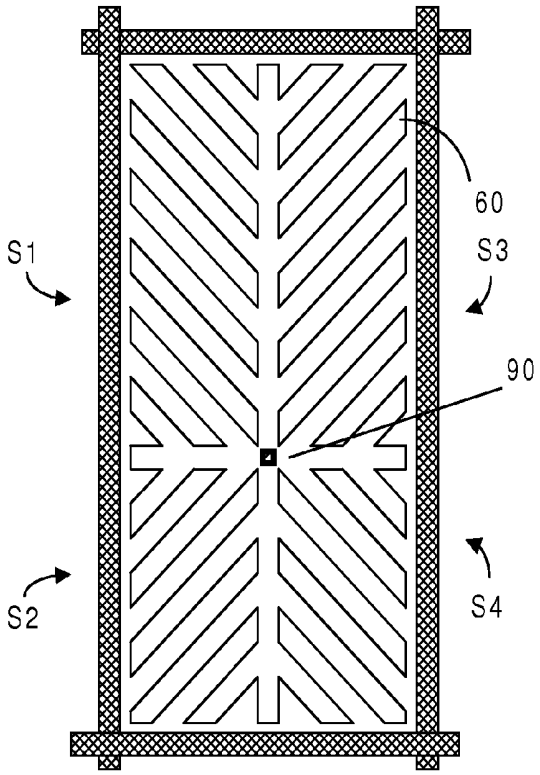


FIG. 9

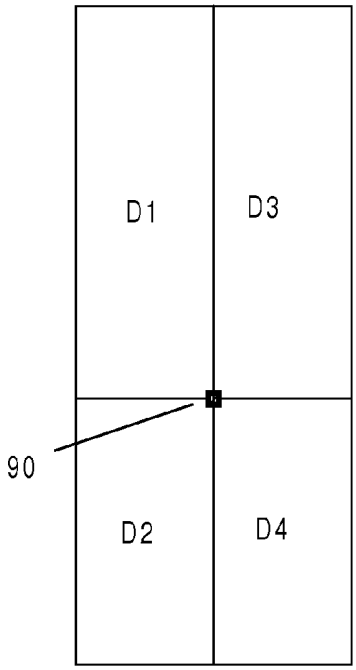


FIG. 10a

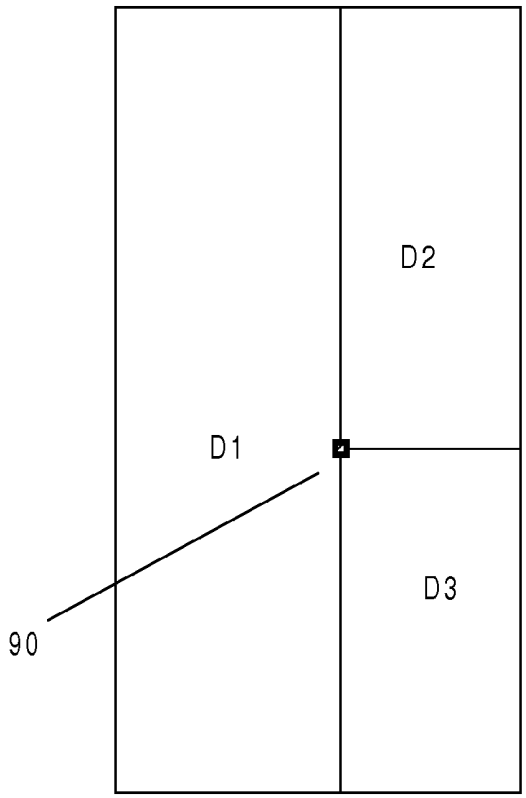


FIG. 10b

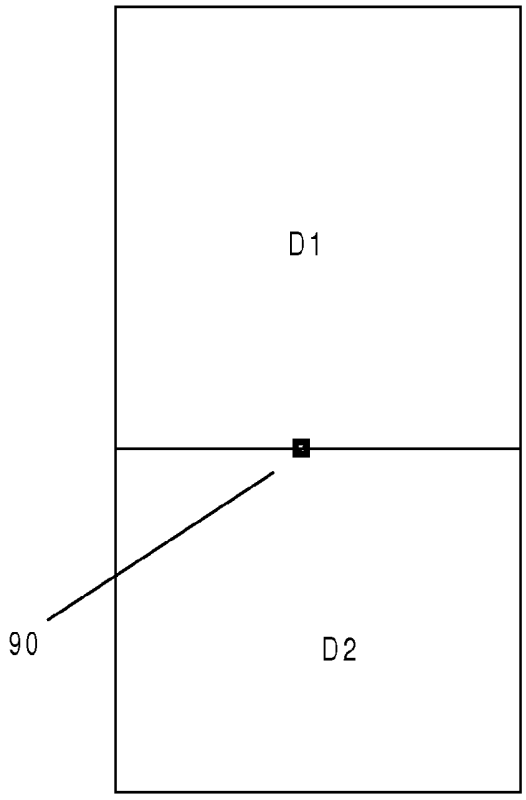


FIG. 10c

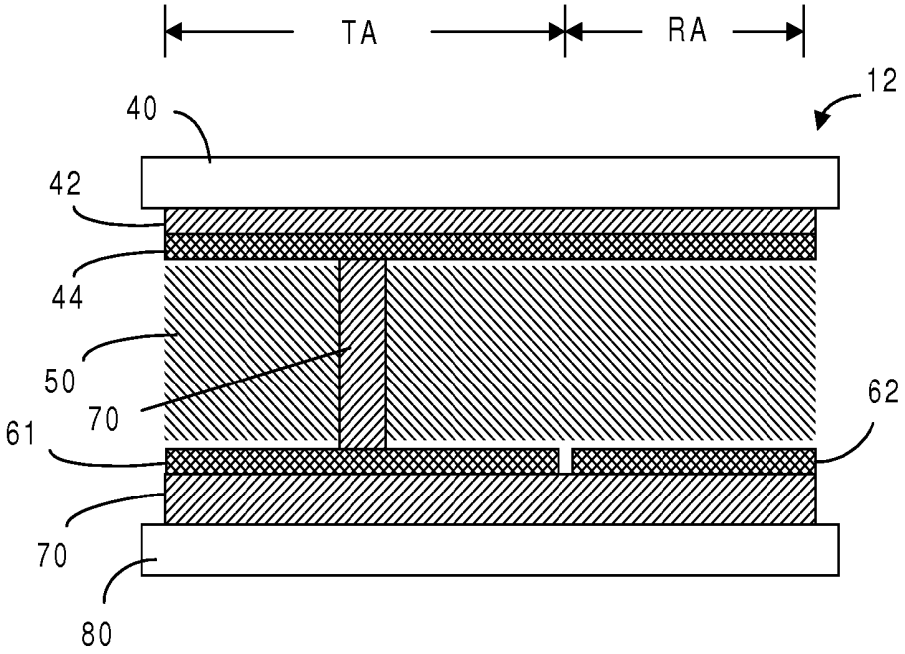


FIG. 11a

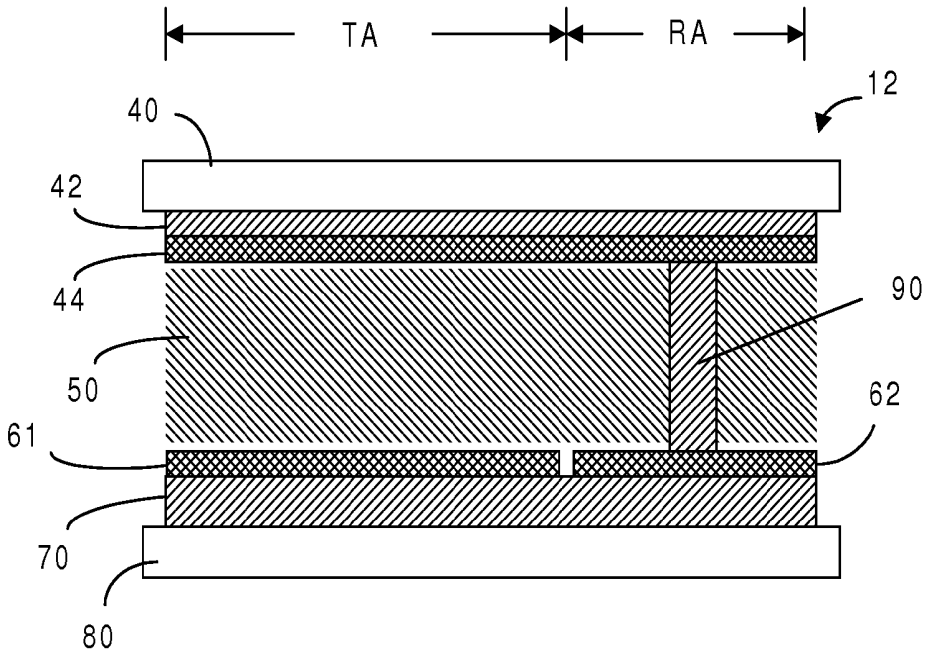


FIG. 11b

PLACEMENT OF SPACERS IN A LIQUID CRYSTAL DISPLAY PANEL

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 11/453,189, filed on Jun. 13, 2006.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to a liquid crystal display and, more particularly, to driving the sub-pixels in the liquid crystal display.

[0004] 2. Description of the Prior Art

[0005] As known in the art, a color liquid crystal display (LCD) panel **1** has a two-dimensional array of pixels **10**, as shown in FIG. **1**. Each of the pixels comprises a plurality of sub-pixels, usually in three primary colors of red (R), green (G) and blue (B). These RGB color components can be achieved by using respective color filters. FIG. **2** illustrates a plan view of the pixel structure in a conventional transmissive LCD panel. As shown in FIG. **2**, a pixel **10** can be divided into three sub-pixels **12**R, **12**G and **12**B. Each pixel is controlled by a gate line **30**, and the sub-pixels **12**R, **12**G and **12**B are controlled by data lines **21**, **22** and **23**, respectively. The structure of a typical transmissive LCD sub-pixel is shown in FIG. **3**. As shown, the LCD sub-pixel **12** comprises a color filter layer **42** and an ITO electrode **44** disposed on an upper substrate **40**. In the lower section of the LCD sub-pixel, a lower transmissive electrode **60** and a device layer **70** are disposed on a lower substrate **80**. The sub-pixel **12** further comprises a liquid crystal layer **50** disposed between the upper and lower electrodes **44** and **60**. The upper electrode **44** is electrically connected to a common voltage. A back-light source located behind the LCD panel is used to provide illumination. As shown in FIG. **4**, the lower electrode is electrically connected to a data line m through a switching element or thin-film transistor (TFT), which is turned on by a signal on the gate line n. The common line is used for providing the common voltage to the upper electrode.

[0006] In a transflective liquid crystal display panel, as shown in FIG. **5**, each sub-pixel is generally divided into a transmission area (TA) and a reflection area (RA). The transmission area has a transmissive electrode **61** and the reflection area has a reflective electrode **62**. In the transmission area, light from the back-light source enters the pixel area through a lower substrate **80** and goes through the transmissive electrode **61**, the liquid crystal layer **50**, the color filter layer **42** and the upper substrate **40**. In the reflection area, light from above the upper substrate **40** goes through the upper substrate **40**, the color filter layer **42** and the liquid crystal layer **50** before it is reflected by the reflective electrode **62**.

[0007] As known in the art, there are many more layers in each pixel for controlling the optical behavior of the liquid crystal layer. These layers may include one or more passivation layers disposed on the lower substrate. Various components such as storage capacitors are also disposed on the lower substrate. As it is known in the art, an LCD panel also has quarter-wave plates and polarizers. Moreover, the device layer **70** may contain a number of metal lines or areas used as gate lines, data lines, capacitors and so forth. These metal lines and areas are covered with one or more dielectric layers. The lower electrodes are usually deposited on top of the dielectric layers.

[0008] In order to achieve a liquid crystal layer of a certain thickness, spacers are generally used to control the gap between the lower and upper substrates. If the spacers are not located properly in the liquid crystal display panel, line defects may occur.

[0009] It is desirable and advantageous to provide a method for disposing the spacers in a liquid crystal display panel so as to improve the viewing quality of the display.

SUMMARY OF THE INVENTION

[0010] The present invention uses a plurality of spacers to control the gap in a liquid crystal display panel. In particular, when a spacer is associated with an electrode in the lower substrate, it is located substantially at the center of the electrode. The lower substrate is where the TFTs, gate lines and data lines are disposed. In a transflective LCD sub-pixel, a spacer may be disposed at the center of one of the transmissive and reflective electrodes. Alternatively, a spacer is disposed at the center of each of the transmissive and reflective electrodes. When the electrode in a sub-pixel comprises different sections to affect the alignment of the liquid crystal layer associated with the electrode, the spacer is located at the intersection of the sections, if possible, so that the spacer is located at the intersections of different domains of the liquid crystal layer. Those intersections are defined as the centers of domain symmetry. As such, line defects, known as disclination, arising from singularities in the orientation order in a director field associated with the liquid crystal layer can be minimized or eliminated.

[0011] Thus, the first aspect of the present invention provides a liquid crystal display panel wherein a plurality of spacers are used to control the gap and the spacers are positioned substantially at one of the centers of domain symmetry in the sub-pixels. The second aspect of the present invention provides a method of placing and positioning the spacers in such a manner in a liquid crystal display panel.

[0012] The present invention will become apparent upon reading the description taken in conjunction with FIGS. **6** to **11***b*.

[0013] These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is a schematic representation of a liquid crystal display panel.

[0015] FIG. **2** is a schematic representation of a pixel showing the pixel structure in a color LCD panel.

[0016] FIG. **3** is a cross sectional view of a sub-pixel showing various layers in an LCD panel.

[0017] FIG. **4** is a plan view of a sub-pixel showing a transmissive electrode in a transmissive LCD panel.

[0018] FIG. **5** is a cross sectional view of a sub-pixel in a transflective LCD panel showing a transmissive electrode and a reflective electrode.

[0019] FIG. **6** is a schematic representation of a sub-pixel in a transmissive LCD, showing the preferred location of a spacer, according to the present invention.

[0020] FIG. **7***a* is a schematic representation of a sub-pixel in a transflective LCD, showing the preferred location of the spacer, according to one embodiment of the present invention.

[0021] FIG. **7***b* is a schematic representation of a sub-pixel in a transflective LCD, showing the location of the spacer, according to another embodiment of the present invention.

[0022] FIG. **7***c* is a schematic representation of a sub-pixel in a transflective LCD having two spacers, according to the present invention.

[0023] FIG. **8***a* is a schematic representation of a pixel with three color sub-pixels wherein one spacer is disposed in each color sub-pixel.

[0024] FIG. **8***b* is a schematic representation of a pixel with three color sub-pixels wherein a spacer is disposed in one of the sub-pixels.

[0025] FIG. **8***c* is a schematic representation of a pixel with three color sub-pixels wherein spacers are disposed in two of the sub-pixels.

[0026] FIG. **9** shows the preferred location of a spacer in a sub-pixel with a strip-like electrode.

[0027] FIG. **10***a* shows the preferred location of a spacer in a sub-pixel wherein the liquid crystal layer in the sub-pixel is aligned differently in four domains.

[0028] FIG. **10***b* shows the preferred location of a spacer in a sub-pixel wherein the liquid crystal layer in the sub-pixel is aligned differently in three domains.

[0029] FIG. **10***c* shows the preferred location of a spacer in a sub-pixel wherein the liquid crystal layer in the sub-pixel is aligned differently in two domains.

[0030] FIG. **11***a* is a cross sectional view of a sub-pixel in a transflective LCD, showing the preferred location of the spacer, according to one embodiment of the present invention.

[0031] FIG. **11***b* is a cross sectional view of a sub-pixel in a transflective LCD, showing the location of the spacer, according to another embodiment of the present invention.

DETAILED DESCRIPTION

[0032] Line defects, known as disclination, may occur in a liquid crystal display. These defects arise from singularities in the orientation order in a director field associated with the liquid crystal layer. The orientation order is associated with a domain in the liquid crystal layer in a pixel or sub-pixel. The location of a spacer in the pixel or sub-pixel may enhance the line defects. In particular, when the spacers are fabricated in a photo-lithographic or photo-etching process, the location of these photo-spacers may affect the alignment of the liquid crystal molecules around the photo-spacers. Certain misalignment produces disclination lines and affects the view quality of the LCD panel. For example, the disclination lines may give rise to a defect known as image retention.

[0033] The present invention provides a way of placing the photo-spacers in an LCD panel so that that the occurrence of disclination lines can be reduced or eliminated. It should be noted that, in an LCD panel having a 2-dimentional array of pixels, it may not be necessary that each of the pixels will have a spacer disposed therein. However, when a pixel has one or more spacers disposed therein, each spacer is located at a center of symmetry of the electrode associated with that spacer.

[0034] In a sub-pixel that has only one lower electrode to control the alignment of the liquid crystal layer in that sub-pixel, the spacer is located substantially at the center of the electrode. As shown in FIG. **6**, only one lower electrode **60** is used, together with the upper electrode (see FIG. **3**), to control the liquid crystal layer in the sub-pixel **12**. The lower electrode **60** is operatively connected to a data line via a TFT, which is controlled by a gate line. The TFT, the gate line and the data line are generally fabricated in the device layer **70** and the electrode **60** is disposed on top of the device layer (see FIG. **3**). The electrode **60** is made of an optically transparent, electrically conductive material such as indium tin-oxide (ITO). In this case, a spacer **90** is disposed substantially at the center of the lower electrode **60**.

[0035] In a sub-pixel having two lower electrodes to separately control the alignment of the liquid crystal layer in that sub-pixel, one or two spacers may be used. FIGS. **7***a* to **7***c* illustrate a typical sub-pixel in a transflective LCD panel, wherein electrode **61** is a transmissive electrode and electrode **62** is a reflective electrode. The reflective electrode is usually made of an reflective metal, such as aluminum. If one spacer is used in the sub-pixel **12** having lower electrodes **61** and **62**, the spacer **90** can be located at the center of the transmissive electrode **61**, as shown in FIG. **7***a*. Alternatively, the spacer **90** can be located at the center of the reflective electrode **62**, as shown in FIG. **7***b*. If two spacers are used, then one spacer is located at the center of the transmissive electrode **61** and the other spacer is located at the center of the reflective electrode **62**, as shown in FIG. **7***c*.

[0036] In a pixel **10** with a plurality of color sub-pixels **12**, as shown in FIGS. **8***a* to **8***c*, each sub-pixel **12** has a separate lower electrode **60**. One or more spacers can be used. If three spacers are used in the pixel **10**, as shown in FIG. **8***a*, it is preferred that each spacer **90** is located at the center of a different electrode **60**. If only one spacer **90** is used, then it can located at the center of one of the electrodes **60**, as shown in FIG. **8***b*. If two spacers **90** are used, then the spacers are separately located at any two of the sub-pixels **12**, with each spacer **90** being located at the center of one lower electrode **60**, as shown in FIG. **8***c*.

[0037] In a pixel or sub-pixel where a strip-like electrode is used to affect the alignment of the liquid crystal layer above the electrode, as shown in FIG. **9**, one electrode is effectively divided into four electrically connecting sections S**1**, S**2**, S**3** and S**4**, with the orientation of the strips in one section being different from that in the adjacent section. As such, it is possible that the alignment orientation of the liquid crystal layer in S**1** and S**4** is different from that in S**2** and S**3**. In this type of LCD, it is preferred that the spacer **90** is located at the common corner of the four sections.

[0038] It should be noted that, although only one strip-like electrode is used to control the liquid crystal layer in a sub-pixel or pixel, the spacer is not necessarily located at the center of electrode such as that shown in FIG. **6**. In the sub-pixel as shown in FIG. **6**, it is likely that the liquid crystal layer associated with the lower electrode has substantially one alignment orientation. In such as case, the liquid crystal layer associated with the lower electrode **60** is said to have only one domain. However, in the sub-pixel as shown in FIG. **9**, the liquid crystal layer associated with the lower electrode **60** is likely to have four domains, each in a different section. The domains are shown in FIG. **10***a*. As shown in FIG. **10***a*, domains D**1**, D**2**, D**3** and D**4** are corresponding to sections S**1**, S**2**, S**3** and S**4** of FIG. **9**.

[0039] When the liquid crystal layer in a sub-pixel or pixel has more than one joining domain, it is preferred that a spacer is placed at the center of symmetry of the domains. For

example, in a sub-pixel having four domains D1, D2, D3 and D4 as shown in FIG. **10***a*, the center of symmetry of the domains is defined as the joining point of the four domains. In a sub-pixel having three domains D1, D2 and D3 as shown in FIG. **10***b*, the center of symmetry of the domains is defined as the point shared by all three domains. In a sub-pixel having two domains D1 and D2 as shown in FIG. **10***c*, the center of symmetry of the domains is defined as the center of the borderline of the two domains.

[0040] In FIG. **6**, it is likely that only one liquid crystal domain is associated with the lower electrode **60**. Thus, the center of symmetry of the domain is the same as the center of the lower electrode. In FIGS. **7***a* to **7***c*, the alignment orientation of the liquid crystal layer associated with the lower electrode **61** and that associated with the lower electrode **62** may be the same or different. Thus, the liquid crystal layer in the same sub-pixel **12** may have two domains. However, these domains are said to be non joining because the electrodes **61** and **62** are electrically separate. Thus, each domain has its own center of symmetry.

[0041] FIG. **11** a is a cross sectional view of a sub-pixel in the transflective LCD of FIG. **7***a*, showing the preferred location of the spacer, according to one embodiment of the present invention. FIG. **11***b* is a cross sectional view of a sub-pixel in a transflective LCD of FIG. **7***b*, showing the location of the spacer, according to another embodiment of the present invention. As shown in FIG. **11***a,* the spacer **90** is disposed between the upper electrode **44** and the lower transmissive electrode **61**. The spacer **90** is positioned substantially at the center of the electrode **61**. The spacer **90** may or may not contact the upper electrode **44**. As shown in FIG. **11***b,* the spacer **90** is disposed between the upper electrode **44** and the lower reflective electrode **62**. The spacer **90** is positioned substantially at the center of the electrode **62**. The spacer **90** may or may not contact the upper electrode **44**.

[0042] Preferably, the spacer **90** is made of a photo-resist material and produced in a photo etching process. It is possible to dispose a black masking material in the color filter layer **42** above the spacer **90**.

[0043] Thus, although the present invention has been described with respect to one or more embodiments thereof, it will be understood by those skilled in the art that the foregoing and various other changes, omissions and deviations in the form and detail thereof may be made without departing from the scope of this invention.

[0044] Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. A liquid crystal display panel comprising:
- a first substrate;
- a second substrate;
- a liquid crystal layer disposed between the first substrate and the second substrate;
- a sub-pixel defined between the first substrate and the second substrate, wherein the sub-pixel comprises a plurality of domains, and the liquid crystal layer has different alignment orientations in the plurality of different domains; and
- a spacer located in the sub-pixel between the first substrate and the second substrate, wherein the spacer is located at a common corner of the plurality of domains.

2. The liquid crystal display panel of claim **1**, further comprising a first electrode layer disposed on the first substrate, the first electrode layer comprising a strip-like electrode corresponding to the sub-pixel, wherein the strip-like electrode includes a plurality of electrically connecting sections, and the orientation in one of the sections is different from that in another section adjacent to the one of the sections.

3. The liquid crystal display panel of claim **2**, wherein the spacer is disposed corresponding to a center of symmetry of the strip-like electrode.

4. The liquid crystal display panel of claim **1**, further comprising a second electrode layer and a color filter layer disposed on the second substrate.

5. The liquid crystal display panel of claim **1**, wherein the spacer is made of a photo-resist material.

6. A liquid crystal display panel comprising:
- a first substrate;
- a second substrate;
- a first electrode layer corresponding to a sub-pixel disposed on the first substrate, having a plurality of connecting sections, wherein the orientation in one of the sections is different from that in another section adjacent to the one of the sections to form a plurality of domains of the sub-pixel; and
- a spacer located in the sub-pixel between the first substrate and the second substrate, wherein the spacer is located at a common corner of the plurality of domains.

7. The liquid crystal display panel of claim **6**, further comprising a liquid crystal layer disposed between the first substrate and the second substrate.

8. The liquid crystal display panel of claim **6**, wherein the first electrode layer is strip-like.

9. The liquid crystal display panel of claim **6**, wherein the spacer is disposed corresponding to a center of symmetry of the first electrode layer.

10. The liquid crystal display panel of claim **6**, further comprising a second electrode layer and a color filter layer disposed on the second substrate.

11. The liquid crystal display panel of claim **6**, wherein the spacer is made of a photo-resist material.

* * * * *

专利名称(译)	在液晶显示板中放置垫片		
公开(公告)号	US20100265450A1	公开(公告)日	2010-10-21
申请号	US12/829393	申请日	2010-07-02
[标]申请(专利权)人(译)	范翔PIN 陈遐杰 孙伟杰		
申请(专利权)人(译)	樊祥-PIN 陈亚CHIEH 太阳wei-chieh		
当前申请(专利权)人(译)	友达光电.		
[标]发明人	FAN HSIANG PIN CHEN YA CHIEH SUN WEI CHIEH		
发明人	FAN, HSIANG-PIN CHEN, YA-CHIEH SUN, WEI-CHIEH		
IPC分类号	G02F1/1339		
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摘要(译)

多个间隔物用于控制液晶显示板中的间隙。当间隔物与下基板中设置有开关元件和数据线的电极相关联时，它基本上位于电极的中心。在透反射LCD子像素中，间隔物可以设置在透射和反射电极之一的中心。或者，间隔物设置在每个透射和反射电极的中心。当子像素中的电极包括不同的部分以影响与电极相关联的液晶层的对准时，如果可能的话，间隔物位于这些部分的交叉处，使得间隔物位于不同的交叉点处。液晶层的区域。