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(54) **LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF FABRICATING THE SAME**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
G02F 1/1339 (2006.01)

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

(58) **Field of Classification Search** 349/156, 349/155, 153, 138, 187, 106, 110, 189
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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7,342,635 B2 * 3/2008 Choi 349/156

* cited by examiner

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(57) **ABSTRACT**

A liquid crystal display device includes: a first substrate having a plurality of gate lines and a plurality of data lines crossing each other; a second substrate facing the first substrate; a first pattern spacer having an inverse tapered shape on an inner surface of the first substrate; a second pattern spacer having an inverse tapered shape on an inner surface of the second substrate; a seal pattern on a peripheral edge of the first and second substrates; and a liquid crystal layer between the first and second substrates.

16 Claims, 3 Drawing Sheets

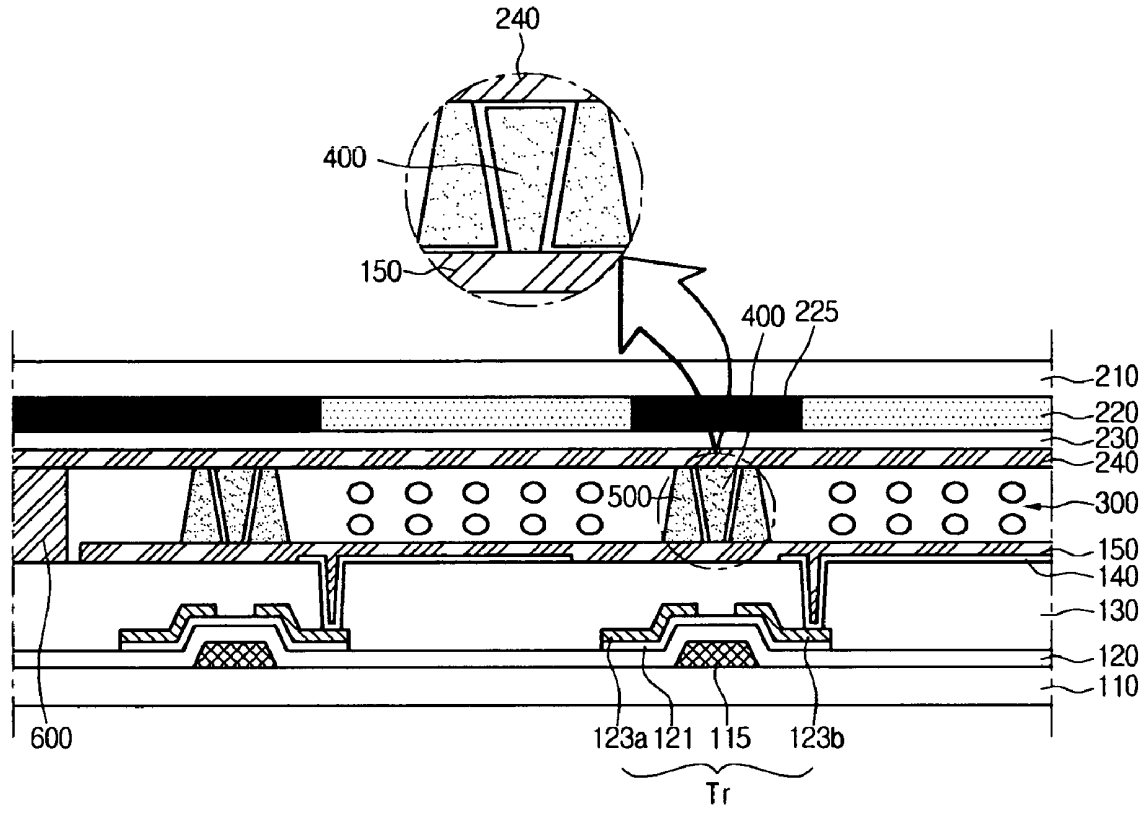


Fig.1
Related Art

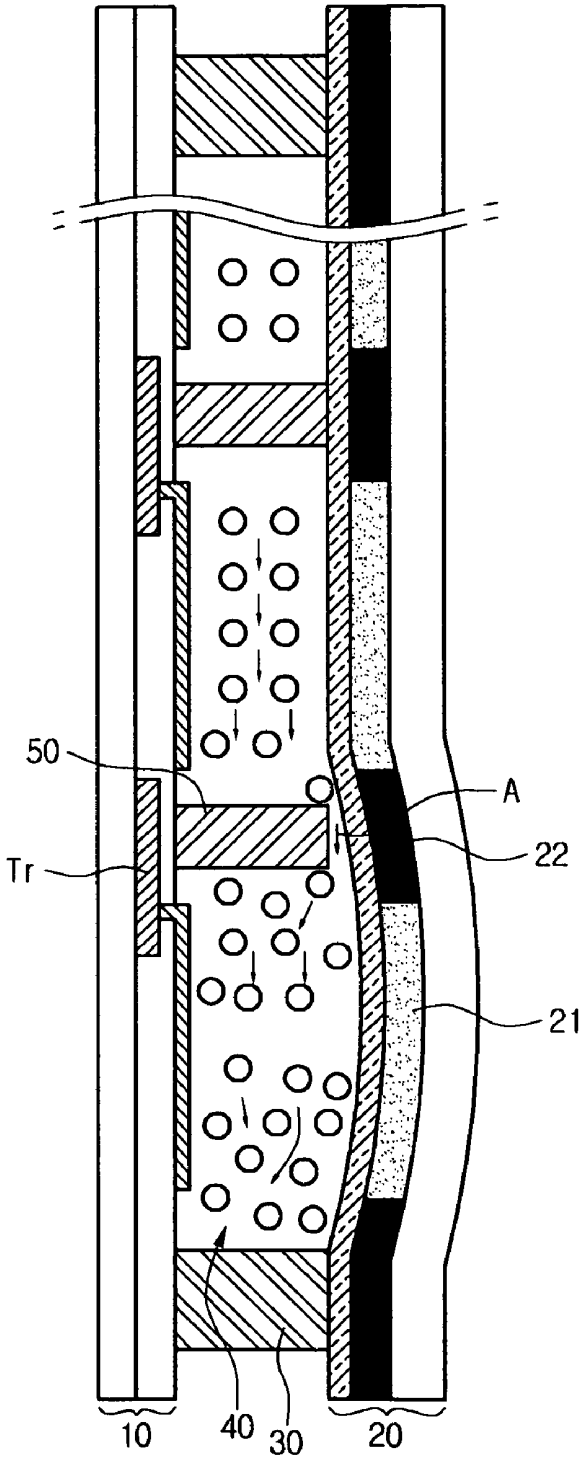


Fig.2

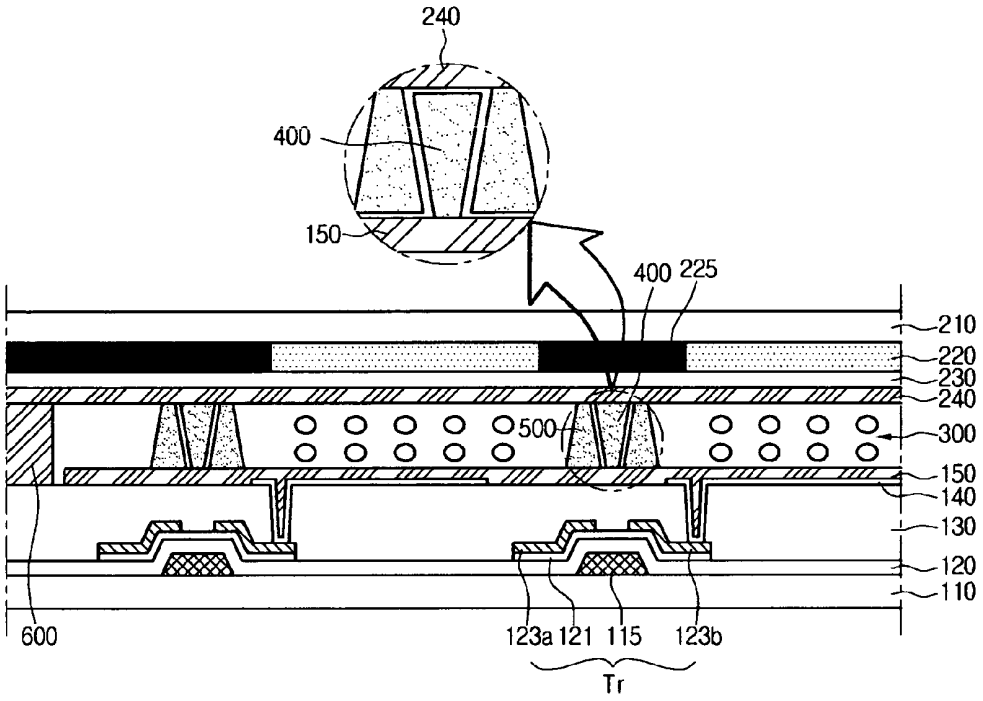

240
400
150
400
225
210
220
230
240
500
300
150
140
130
120
110
600
123a
121
115
123b
Tr

Fig.3A

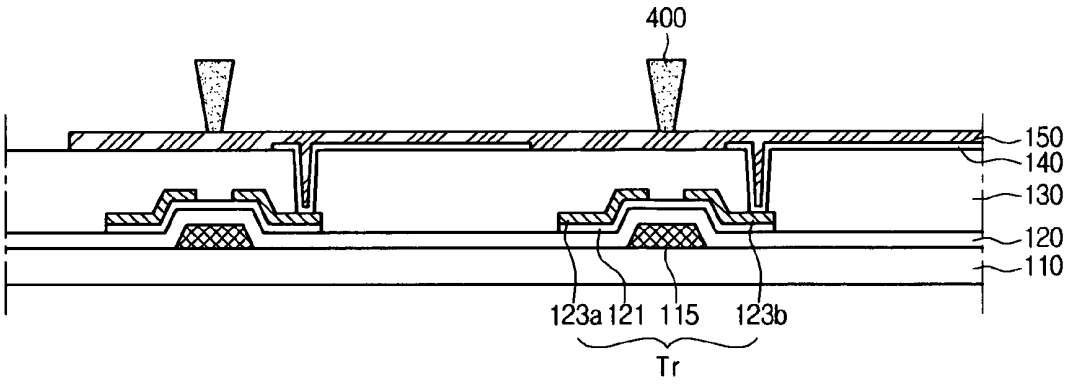

400
150
140
130
120
110
123a
121
115
123b
Tr

Fig.3B

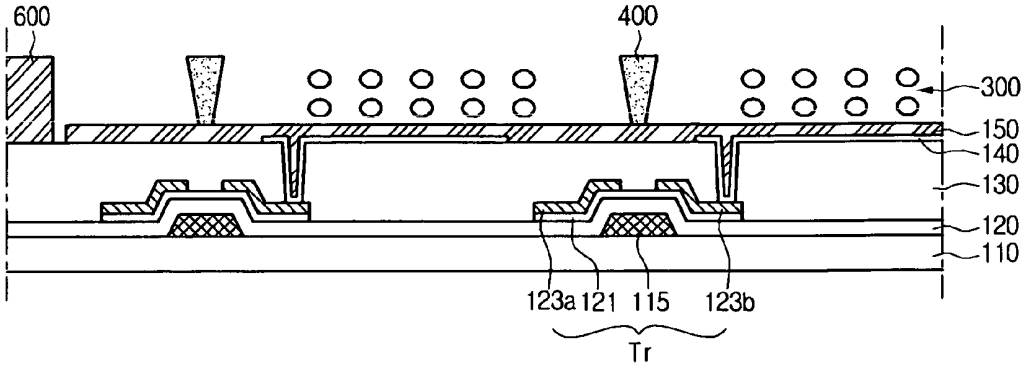


Fig.3C

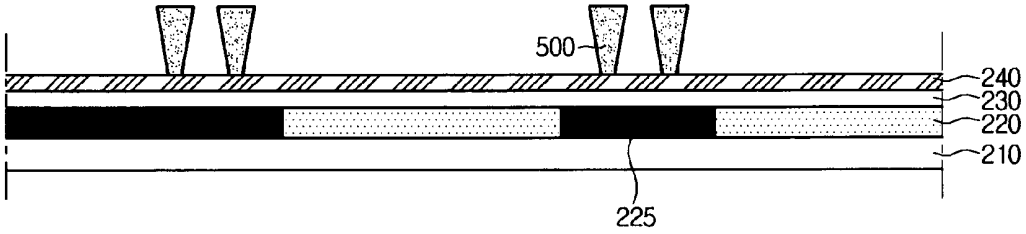
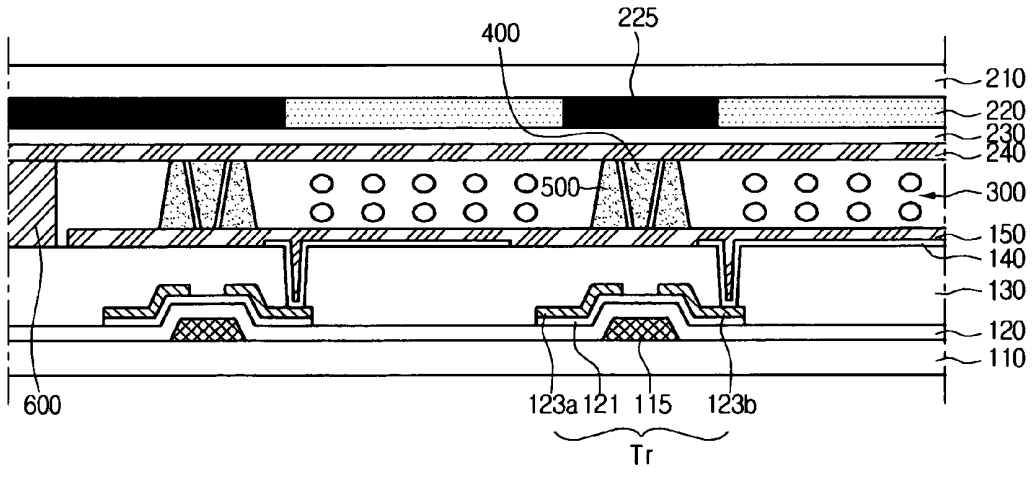


Fig.3D



LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF FABRICATING THE SAME

The present invention claims the benefit of Korean Patent Application No. 090417/2005 filed in Korea on Sep. 28, 2005, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a display device, and more particularly, to a liquid crystal display device and a method of fabricating the same.

2. Description of the Related Art

The liquid crystal display (LCD) device has been most favored recently as an efficient and value-added next generation display device, due to its low power consumption and its portability. In general, the LCD includes a lower substrate and an upper substrate arranged facing the lower substrate with a liquid crystal layer interposed between the lower substrate and the upper substrate. The lower substrate has a thin film transistor and a pixel electrode formed thereon. The upper substrate has a black matrix layer, a color filter layer and a common electrode formed thereon. The lower and upper substrates maintain a constant cell gap using a spacer. In such an LCD, an electric field is formed between the lower and upper substrates by a pixel electrode and a common electrode to align liquid crystal molecules, and light transmittance is adjusted through the alignment of the liquid crystal molecules to thereby display images. The picture quality of an LCD device is influenced by the integrity of the liquid crystal layer interposed between the two substrates. For instance, if the liquid crystal material is over-filled or expands due to high temperature, gravity failure may occur.

FIG. **1** is a cross-sectional view of the related art LCD showing a gravity failure. As shown in FIG. **1**, the related art LCD includes a lower substrate **10**, an upper substrate **20**, and a liquid crystal layer **40** interposed between the lower substrate **10** and the upper substrate **20**. The lower substrate **10** has a thin film transistor (Tr) formed thereon. The upper substrate **20** has a color filter layer **21** and a black matrix layer **22** formed thereon. The lower substrate **10** and the upper substrate **20** are attached by a seal pattern **30**. The lower and upper substrates **10** and **20** maintain a constant cell gap using pattern spacers **50**. The liquid crystal layer **40** is formed by injecting a liquid crystal material into an inner space between the lower and upper substrates **10** and **20** defined by the pattern spacers **50**.

A proper amount of the liquid crystal material should be injected into the inner space. However, it is difficult to control the injection amount of the liquid crystal material. Sometimes, the liquid crystal material may over-fill the inner space, which can result in a gravity failure. Over-filling can cause other problems. For example, when the temperature of the liquid crystal material is increased due to an external environment, the volume of the liquid crystal expands to become larger than the inner space. If such an expansion occurs, the pattern spacers **50** are detached from one of the two substrates such that a liquid crystal path 'A' may be generated. Through the liquid crystal path 'A', the liquid crystal is collected downward, so that the cell gap becomes non-uniform. The non-uniform cell gap deteriorates the quality of the LCD and may cause a touch failure. Gravity failure and the touch brightness failure become exacerbated as the screen size of the LCD increases.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a liquid crystal display and a method of fabricating the same that substantially obviate one or more problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a liquid crystal display and a method of fabricating the same for preventing touch brightness failure in an LCD panel.

Another object of the present invention is to provide a liquid crystal display and a method of fabricating the same for preventing gravity failure in an LCD panel.

An object of the present invention is to provide a liquid crystal display and a method of fabricating the same to maintain the cell gap an LCD panel.

Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention can be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, there is provided a liquid crystal display device including: a first substrate having a plurality of gate lines and a plurality of data lines crossing each other; a second substrate facing the first substrate; a first pattern spacer having an inverse tapered shape on an inner surface of the first substrate; a second pattern spacer having an inverse tapered shape on an inner surface of the second substrate; a seal pattern on a peripheral edge of the first and second substrates; and a liquid crystal layer between the first and second substrates, wherein the first and second pattern spacers have a tapered shape.

In another aspect, a liquid crystal display device includes: a first substrate having a plurality of gate lines and a plurality of data lines crossing each other; a second substrate facing the first substrate; a first pattern spacer having an inverse tapered shape on an inner surface of the first substrate; a second pattern spacer having an inverse tapered shape on an inner surface of the second substrate; a seal pattern on a peripheral edge of the first and second substrates; and a liquid crystal layer between the first and second substrates, wherein the first and second pattern spacers are interleaved.

In another aspect, there is provided a method of fabricating a liquid crystal display device that includes providing a first substrate having a thin film transistor formed on a unit pixel region defined by a plurality of gate lines crossing a plurality of data lines, forming a passivation layer having a contact hole exposing a drain electrode of the thin film transistor, forming a pixel electrode connected with the drain electrode through the contact hole, forming a photoresist film on the passivation layer, and exposing and developing the photoresist film to form a first pattern spacer having a tapered shape.

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

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incor-

porated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention.

FIG. **1** is a cross-sectional view of a related art LCD showing a gravity failure.

FIG. **2** is a cross-sectional view of an LCD according to an embodiment of the present invention.

FIGS. **3**A through **3**D are cross-sectional views illustrating a method of fabricating an LCD according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The invention can, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the invention to those skilled in the art. In the drawings, the thicknesses of layers and regions are exaggerated for clarity. Like reference numerals in the drawings denote like elements.

FIG. **2** is a cross-sectional view of an LCD according to an embodiment of the present invention. As shown in FIG. **2**, the LCD includes a first substrate **110**, a second substrate **210**, and a liquid crystal layer interposed between the first and second substrates **110** and **210**. The first substrate **110** has thin film transistors (Tr) and a first pattern spacer **400** formed thereon. The second substrate **210** has a color filter layer **220** and a second pattern spacer **500** formed thereon. The first and second substrates **110** and **210** are attached to each other by a seal pattern **600** formed on a peripheral edge of the two substrates for maintaining a constant cell gap.

The first pattern spacer **400** and the second pattern spacer **500** have inverse tapered shapes that complement each other. More particularly, an inverse tapered shape has a bottom surface area contacting the substrate that is smaller than an opposite top surface area. The first pattern spacer **400** and the second pattern spacer **500** are disposed to be interlocked with each other. In other words, the second pattern spacer **500** can be inserted between the first pattern spacers **400**. In an alternative, the first pattern spacer **400** can be inserted between the second pattern spacers **500**. Such an interlocked structure prevents a liquid crystal path from forming between regions, and the first and second substrates **110** and **210** from separating from each other.

Referring to FIG. **2**, a plurality of gate lines (not shown) and a plurality of data lines (not shown) are arranged crossing each other on the first substrate **110**, and a thin film transistor (Tr) is disposed adjacent to a crossing of the gate line and the data line within each unit pixel. Over the entire surface of the first substrate **110** including the thin film transistor (Tr), a passivation layer **130** is disposed. The passivation layer **130** is an inorganic insulation material, such as silicon nitride or silicon oxide. Herein, the passivation layer **130** is provided with a contact hole exposing a drain electrode of the thin film transistor (Tr).

A pixel electrode **140** is positioned on the passivation layer **130** and is connected with the drain electrode through the contact hole. A first alignment film **240** is positioned on the pixel electrode **140**. The first alignment film **240** functions to align the liquid crystal molecules of the liquid crystal layer **300** in a selected direction. The first pattern spacer **400** can be positioned on the first alignment layer **240** corresponding to a non-transmission region of the first substrate **110**, such as a region where the thin film transistor, a capacitor or a plurality of interconnection lines are formed. This is because the first pattern spacer **400** affects the light transmittance.

The first pattern spacer **400** can be made of an organic insulation material, such as a negative photoresist material. The organic insulation material can be a Novalac phororesist resin. The first pattern spacer **400** can have an inverse tapered shape. Unlike in the drawing, the first pattern spacer **400** can be formed as a plurality of spacers. Thereafter, the first pattern spacers **500** can be inserted between the second pattern spacers **500** to enhance an adhesive force between the first substrate **110** and the second substrate **210**.

Meanwhile, the second substrate **210** is disposed facing the first substrate **110**. The second substrate **210** includes a black matrix layer **225** formed on a region corresponding to a non-transmission region where the thin film transistor (Tr) is formed, and a color filter layer **220** formed on a region corresponding to a transmission region to express colors. A transparent upper electrode **230** serving as a common electrode is formed on the black matrix layer **225** and the color filter layer **220**, and a second alignment layer **240** is positioned below the upper transparent electrode **230**.

The second pattern spacer **500** is positioned on a region corresponding to the non-transmission region on the second alignment layer **240**, i.e., on a region where the black matrix layer **225** is formed. The second pattern spacer **500** can have an inverse tapered shape. Unlike in the drawing, the second pattern spacer **500** is formed in plurality. This is because the first pattern spacers **400** are interlocked between the second pattern spacers **500** such that the second pattern spacers **500** are not separated from the first substrate **110**. The second pattern spacer **500** can be made of an organic insulation material, such as a negative photoresist material. Alternatively, the second pattern spacer **500** can be formed of a Novalac photoresist resin.

The liquid crystal layer **300** interposed between the first substrate **110** and the second substrate **210** can be a liquid crystal material, such as twisted nematic (TN), super twisted nematic (STN), electrically controlled birefringence (ECB), optically compensated birefringence (OCB), hybrid aligned nematic (HAN) and vertical alignment (VA) modes.

FIGS. **3**A through **3**D are cross-sectional views illustrating a method of fabricating an LCD according to an embodiment of the present invention. Referring to FIG. **3**A, a first substrate **110** is first provided. The first substrate **110** can be a plastic substrate or a glass substrate. A plurality of gate lines and a plurality of data lines perpendicularly cross each other to define a pixel region on the first substrate **110**, and thin film transistors (Tr) are also formed adjacent to the crossings of the pluralities of gate lines and data lines.

Each of the thin film transistors (Tr) is formed by the following process operations. First, a first conductive layer is formed on the first substrate and is then patterned to form a gate electrode **115**. The first conductive layer can be made of a low resistance conductive material, such as, Al, Mo, Cu or an alloy thereof. Thereafter, a gate insulation layer **120** is formed on the entire surface of the first substrate **110**, including the gate electrode **115**. The gate insulation layer **120** can be silicon nitride or silicon oxide formed by chemical vapor deposition (CVD). A silicon layer and a doped amorphous silicon layer are sequentially deposited and are then patterned to form an active layer **121**. Thereafter, a second conductive layer is deposited on the first substrate **110**, including the active layer **121**, and is then patterned to form a source/drain electrode **123***a*/**123***b*. The second conductive layer can be formed of Mo, Cr, Al or an alloy thereof.

Through the above process operations, a thin film transistor (Tr) having the gate electrode **115**, the active layer **121** and the source/drain electrode **123***a*/**123***b* is formed on the first substrate **110**. Thereafter, a passivation layer **130** is formed on the entire surface of the first substrate **110**, including the thin film transistor (Tr). The passivation layer **130** is an inorganic insulation layer, such as silicon nitride or silicon oxide.

A contact hole exposing the drain electrode **123***b* is formed in the passivation layer **130**. Thereafter, a transparent conductive layer is formed on the passivation layer **130** and is then patterned to form a pixel electrode **140**. The pixel electrode **140** can be made of indium tin oxide (ITO), indium zinc oxide (IZO) or indium tin zinc oxide (ITZO). Although not shown in the drawings, a first alignment layer is then formed on the first substrate **110**, including the pixel electrode **140**. The alignment layer **150** can be formed by coating one selected from the group consisting of polyamide, polyimide compound, a polyvinyl alcohol and a polyamic acid. Then, a surface of the coated film is rubbed. Alternatively, the alignment layer **150** can be formed by coating one of polyvinyl cinnamate, polysiloxane cinnamate and cellulose cinnamate compounds, which is then subjected to photo-rubbing.

A negative photoresist material is coated on the first alignment layer **150** to form a photoresist film. The photoresist film is exposed to light and developed to form a first pattern spacer **400**. The negative photoresist material can be a Novalac photoresist resin. The first pattern spacer **400** can have an inverse tapered shape due to the exposure development characteristics of the photoresist material. The first pattern spacer **400** is formed on a region of the first substrate **110** where one of the thin film transistor Tr, a capacitor and the pluralities of gate and data lines is formed.

Referring to FIG. **3**B, a seal pattern **600** is formed on a peripheral edge of the first substrate **110**, and a liquid crystal is dropped on the first substrate **110** to form a liquid crystal layer **300**. The seal pattern **600** can be made of an ultraviolet (UV)-curing sealant rather than a thermal curing sealant. A thermal-curing sealant may contaminate the liquid crystal material.

Referring to FIG. **3**C, a second substrate **210** can be a plastic substrate or a glass substrate. Next a black matrix layer **225** is formed. The black matrix layer **225** shields light from being leaked in the region where a plurality of interconnection lines and thin film transistors are formed. Thereafter, a color filter layer **230** having red (R), green (G) and blue (B) color filter elements is formed thereon. Thereafter, a transparent conductive layer is deposited on the second substrate **210**, including the color filter layer **230** and the black matrix layer **225**, and is then patterned to form an upper electrode **230**. At this time, as aforementioned, a second alignment layer **240** can be further formed on the upper electrode **240**.

A negative photoresist material is coated on the second alignment layer **240**, and is exposed to light and developed to form a second pattern spacer **500**. The second pattern spacer **500** is preferably formed to have a plurality of inverse tapered shape spacers. Because of the availability of space on the black matrix layer **225**, or alternatively, above the black matrix layer **225** on the alignment layer **240**, more second pattern spacers **500** are formed on the second substrate **210** than first pattern spacers **400** formed on the first substrate **110**. As aforementioned, to form the second pattern spacer **500** in the inverse tapered shape, the second pattern spacer **500** is formed of a negative photoresist material. For example, the second pattern spacer **500** can be a Novalac photoresist resin.

Referring to FIG. **3**D, the first substrate **110** and the second substrate **210** are positioned such that a vacuum state can occur between the first and second substrates **110** and **210**. The first pattern spacer **400** and the second pattern spacer **500** are interlocked with each other by the pressure difference created by the vacuum. In other words, the second pattern spacer **500** can be inserted between the first pattern spacers **400** or the first pattern spacer can be inserted between the second pattern spacers **500**. Then, UV is irradiated onto the seal pattern **600** such that the first and second substrates **110** and **210** are attached. The liquid crystal layer **300** is then formed by an injection method using a subsequent vacuum. The LCD panel is sealed, thereby completing an LCD panel.

The above embodiment describes interlocking the first pattern spacer **400** and the second pattern spacer **500** with a vacuum, the first pattern spacer **400** and the second pattern spacer **500** can alternatively be interlocked by sliding the patterns into each other. For example, one of the substrates is held in a fixed position while the other substrate is applied to the one substrate in a slightly offset manner and then the other substrate is slid so as to have the first and second pattern spacers interlock. Prior to sliding and interlocking the first and second pattern spacers, liquid crystal can be dropped on the one substrate to form the liquid crystal layer **300**, which has a seal about the periphery of the substrate. Alternatively, the liquid crystal layer **300** is formed by a vacuum injection method after the substrates are attached by the interlocking first and second pattern spacers. Then, the LCD panel is sealed, thereby completing an LCD panel.

The first pattern spacer **400** formed on the first substrate **110** is interlocked with the second pattern spacer **500** formed on the second pattern spacer **210** or vice versa such that the first and second substrates **110** and **210** are not easily separated. Thus, the interlocking first and second pattern spacers prevent bulging of the LCD panel. Further, the interlocking first and second pattern spacers prevent a liquid crystal material path between regions of the LCD panel. Consequently, a good quality LCD can be fabricated.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A liquid crystal display device comprising:

a first substrate having a plurality of gate lines and a plurality of data lines crossing each other;

a second substrate facing the first substrate;

a plurality of first pattern spacers having an inverse tapered shape on an inner surface of the first substrate;

a plurality of second pattern spacers having an inverse tapered shape on an inner surface of the second substrate;

a seal pattern on a peripheral edge of the first and second substrates; and

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

wherein the first and second pattern spacers are alternately disposed each other.

2. The liquid crystal display device according to claim **1**, wherein the first and second pattern spacers are made of an organic insulation material.

3. The liquid crystal display device according to claim **1**, wherein the first and second pattern spacers are made of a negative photoresist material.

4. The liquid crystal display device according to claim **1**, wherein the first and second pattern spacers are made of Novalac photoresist resin.

5. The liquid crystal display device according to claim 1, wherein the first and second pattern spacers are interlocked with each other.

6. The liquid crystal display device according to claim 1, wherein the first pattern spacers are formed on a region of the first substrate where one of the thin film transistor, a capacitor, and the pluralities of gate and data lines are formed.

7. The liquid crystal display device according to claim 1, wherein the second pattern spacers are formed on a region of the second substrate where a black matrix layer of the second substrate is formed.

8. The liquid crystal display device according to claim 7, wherein more second pattern spacers are formed on the second substrate than first pattern spacers formed on the first substrate.

9. A liquid crystal display device comprising:

a first substrate having a plurality of gate lines and a plurality of data lines crossing each other;

a second substrate facing the first substrate;

a plurality of first pattern spacers having an inverse tapered shape on an inner surface of the first substrate;

a plurality of second pattern spacers having an inverse tapered shape on an inner surface of the second substrate;

a seal pattern a peripheral edge of the first and second substrates; and

a liquid crystal layer between the first and second substrates,

wherein the first and second pattern spacers are interleaved.

10. The liquid crystal display device according to claim 9, wherein the first and second pattern spacers are made of an organic insulation material.

11. The liquid crystal display device according to claim 9, wherein the first and second pattern spacers are made of a negative photoresist material.

12. The liquid crystal display device according to claim 9, wherein the first and second pattern spacers are made of a Novalac photoresist resin.

13. The liquid crystal display device according to claim 9, wherein the first and second pattern spacers are interlocked with each other.

14. The liquid crystal display device according to claim 9, wherein the first pattern spacers are formed on a region of the first substrate where one of the thin film transistor, a capacitor, and the pluralities of gate and data lines are formed.

15. The liquid crystal display device according to claim 9, wherein the second pattern spacers are formed on a region of the second substrate where a black matrix layer of the second substrate is formed.

16. The liquid crystal display device according to claim 14, wherein more second pattern spacers are formed on the second substrate than first pattern spacers formed on the first substrate.

* * * * *

专利名称(译)	液晶显示装置及其制造方法		
公开(公告)号	US7576827	公开(公告)日	2009-08-18
申请号	US11/372082	申请日	2006-03-10
[标]申请(专利权)人(译)	乐金显示有限公司		
申请(专利权)人(译)	LG.PHILIPS LCD CO.，LTD.		
当前申请(专利权)人(译)	LG DISPLAY CO.，LTD.		
[标]发明人	LEE JOON SUK JEE YOUNG SEUNG KIM JEONG OH		
发明人	LEE, JOON SUK JEE, YOUNG SEUNG KIM, JEONG OH		
IPC分类号	G02F1/1339		
CPC分类号	G02F1/13394		
优先权	1020050090417 2005-09-28 KR		
其他公开文献	US20070070284A1		
外部链接	Espacenet USPTO		

摘要(译)

一种液晶显示装置，包括：第一基板，具有多条栅极线和多条彼此交叉的数据线;面向第一基板的第二基板;第一图案间隔物，在第一基板的内表面上具有倒锥形形状;第二图案间隔物，在第二基板的内表面上具有倒锥形形状;在第一和第二基板的外围边缘上的密封图案;以及第一和第二基板之间的液晶层。