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(54) THIN FILM TRANSISTOR LIQUID CRYSTAL DISPLAY WHEREIN THE LOWER ELECTRODE INCLUDES A FIRST ELECTRODE AND A PIXEL ELECTRODE

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(51) **Int. Cl.**^{7} **G02F 1/1343**; G02F 1/136; G02F 1/133

(52) **U.S. Cl.** **349/139**; 349/43; 349/138; 349/141; 349/143

(58) **Field of Search** 349/139, 141, 349/138, 43, 129, 143, 144

(56) **References Cited**

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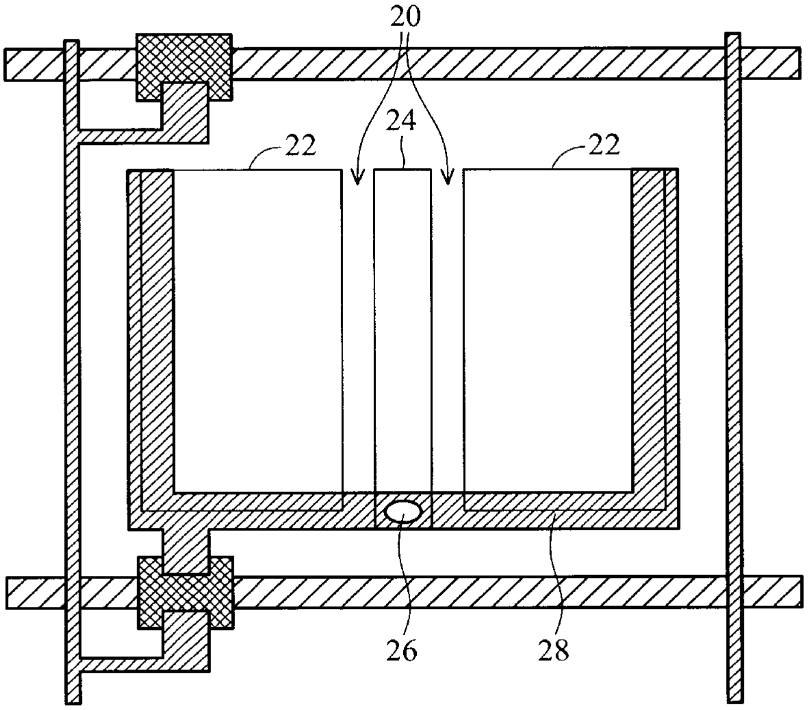
(57) ABSTRACT

A thin film transistor liquid crystal display generates voltage difference between the lower electrodes, then the generating domains are controlled by the voltage difference. The lower electrode is divided into a narrow electrode and a pixel electrode. The pixel electrode is further divided into a plurality of pixel electrodes. The narrow electrode is coupled to a drain or a source of a thin film transistor, and a portion of the pixel electrode is overlapped on the drain/source of the thin film transistor but insulated to the drain/source of the thin film transistor to generate capacitive coupling and make the voltage level of the narrow electrode exceeds that of the pixel electrode. Thus, a horizontal electric fields is formed to generate multiple domains in a signal pixel.

7 Claims, 5 Drawing Sheets



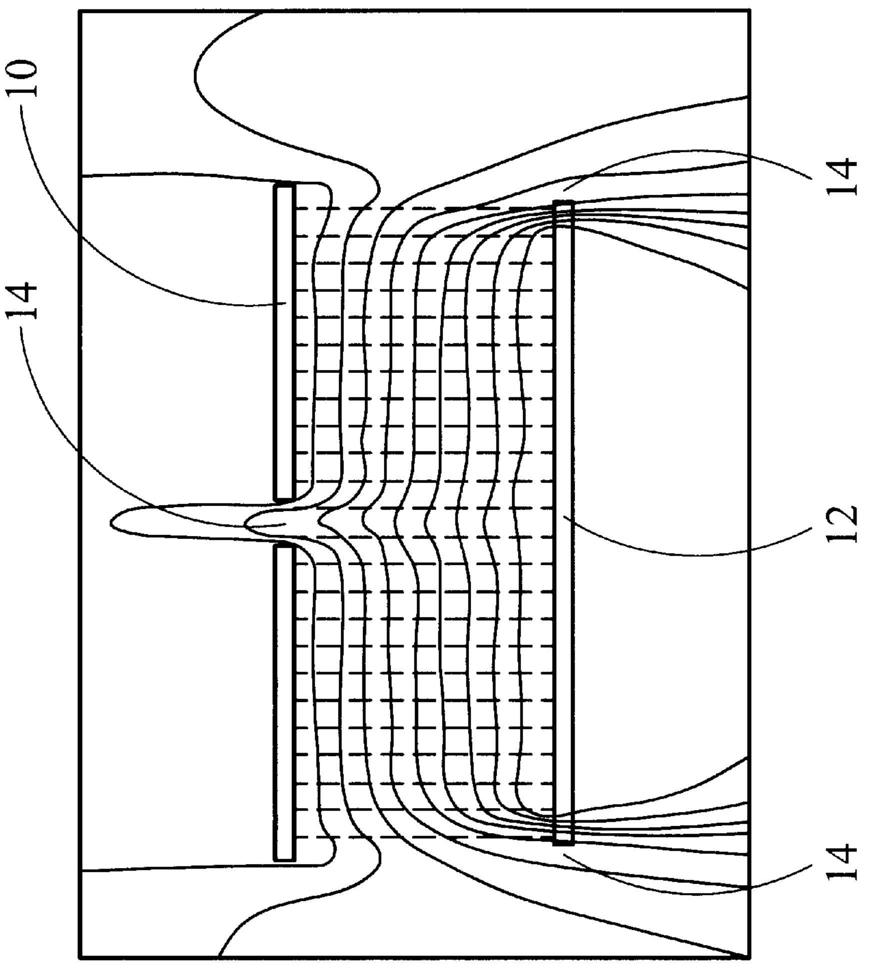


FIG. 1 (PRIOR ART)

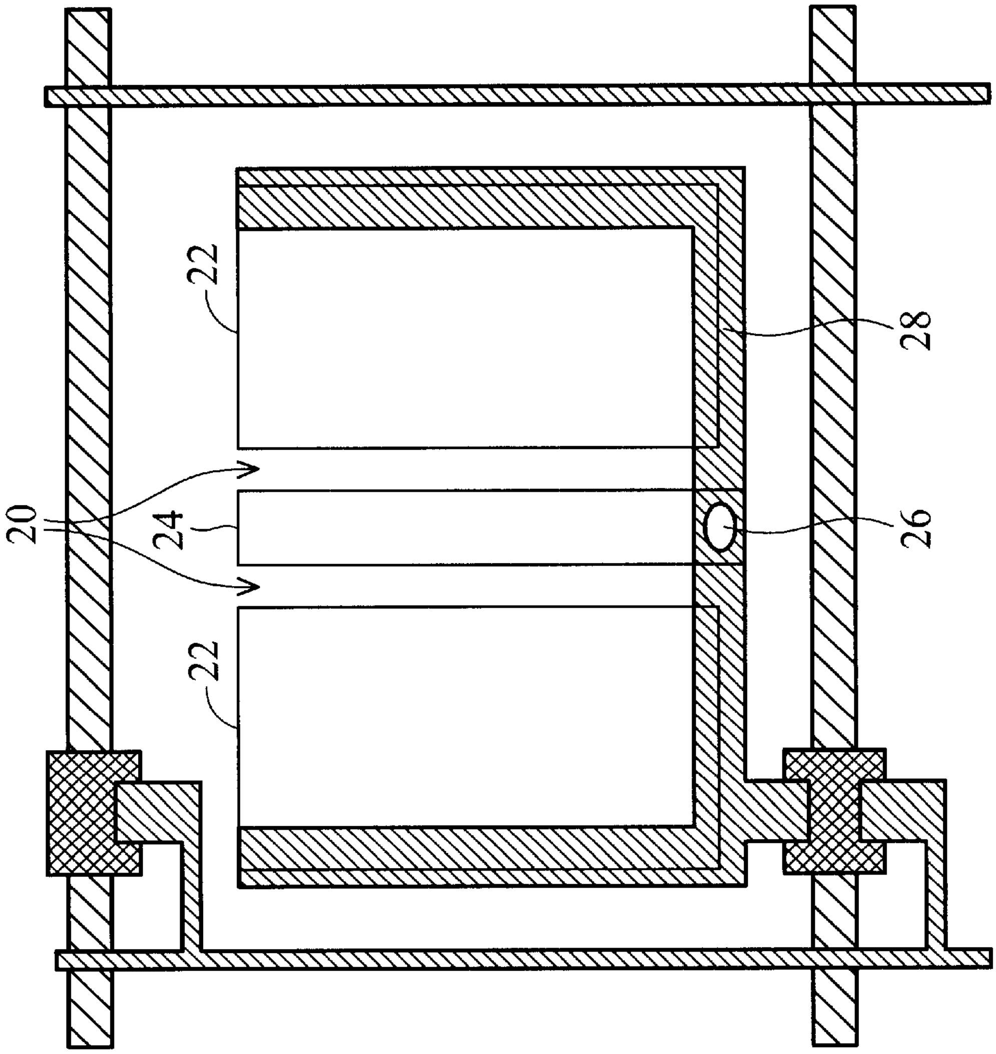


FIG. 2A

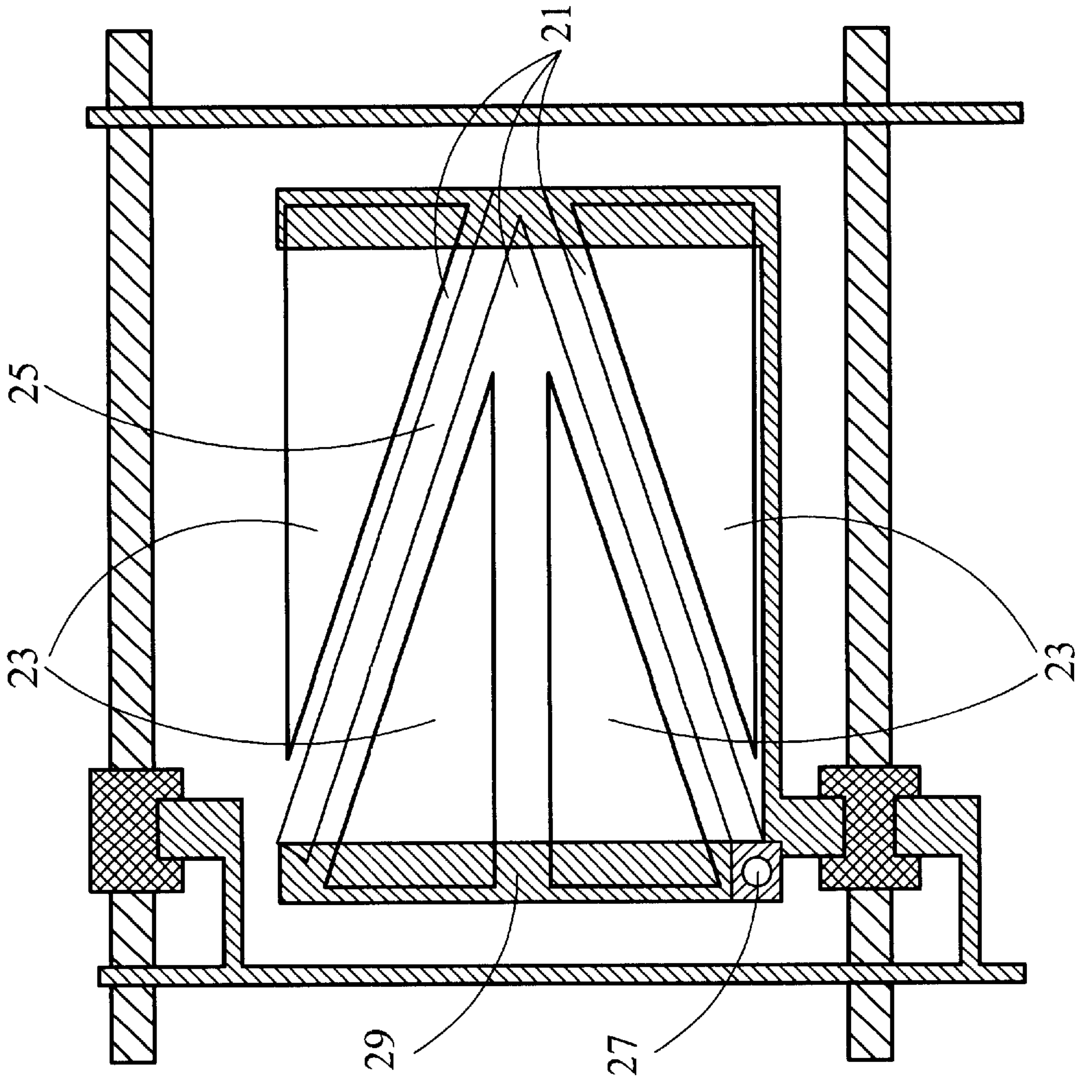


FIG. 2B

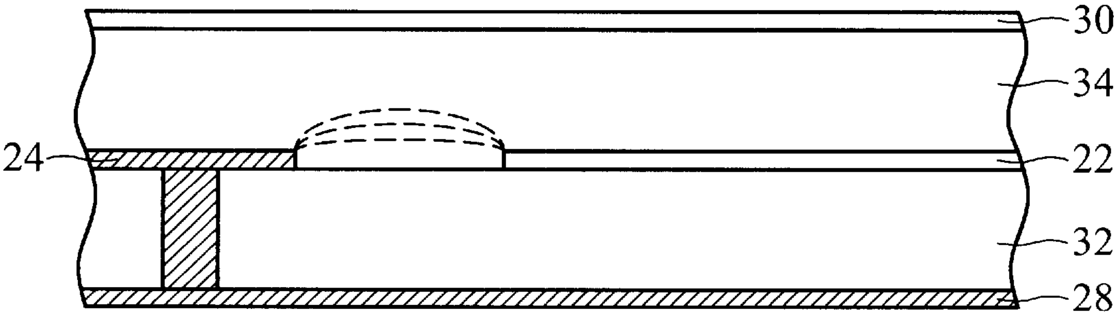

30
34
24
22
32
28

FIG. 2C

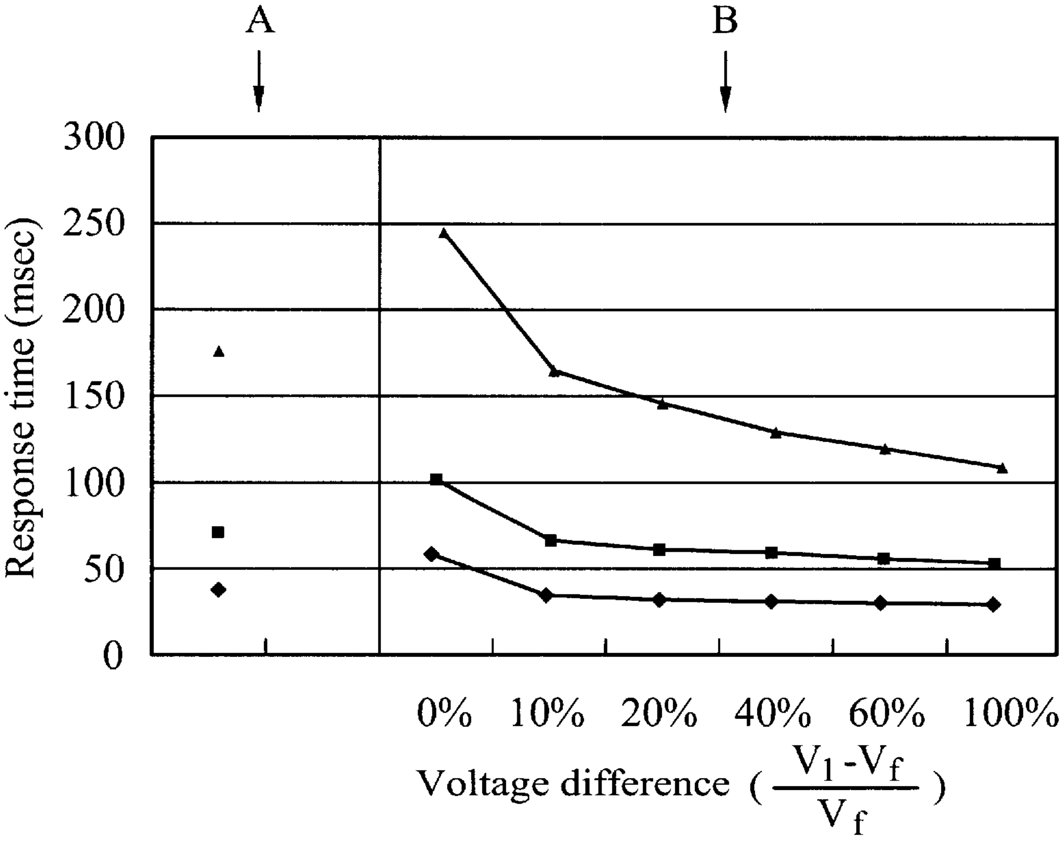

A
B
300
250
200
150
100
50
0
Response time (msec)
0%
10%
20%
40%
60%
100%
Voltage difference ($\frac{V_1 - V_f}{V_f}$)

FIG. 3

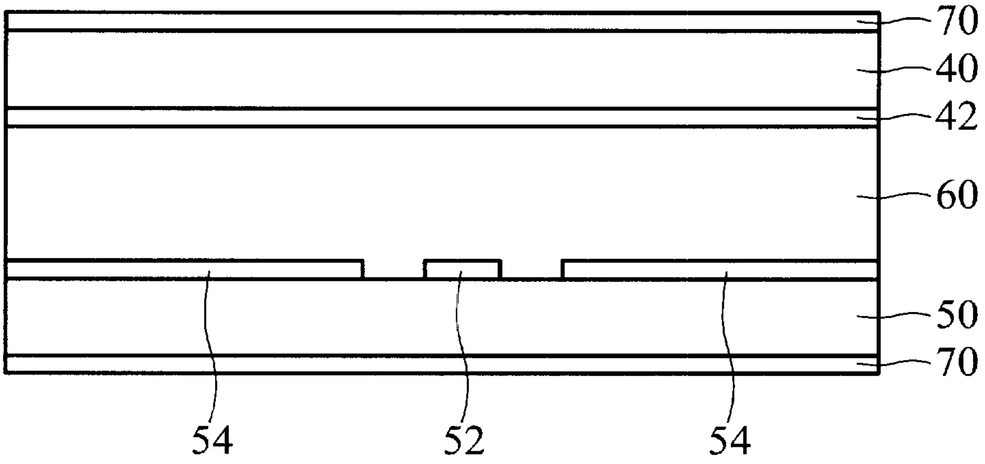


FIG. 4A

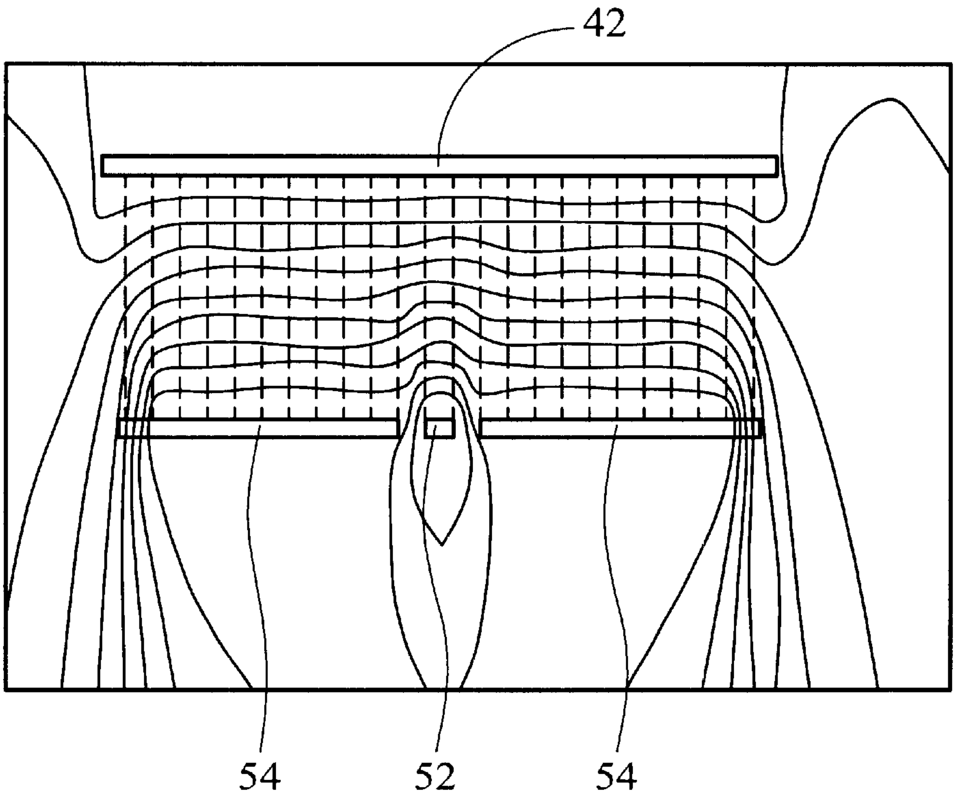


FIG. 4B

THIN FILM TRANSISTOR LIQUID CRYSTAL DISPLAY WHEREIN THE LOWER ELECTRODE INCLUDES A FIRST ELECTRODE AND A PIXEL ELECTRODE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates in general to a thin film transistor liquid crystal display (THT-LCD). In particular, the present invention relates to a thin film transistor liquid crystal display generating voltage by capacitive coupling to form multiple domains.

2. Description of the Related Art

With liquid crystal display (LCD) applied to notebooks and monitors, the market for LCD is getting larger. When large, high resolution LCD panels are used for desktop monitors, wide viewing angle and quick response time is required.

For vertically aligned (VA) LCD, controlling the domain of the liquid crystal molecules to obtain a wider viewing angle for the LCD is an important technology. Most conventional LCDs are 90° twisted nematic type (TN) LCD, which have LCD panel and polarizers pasted on the outer surface thereof. The disadvantage of the conventional LCD is that the visual angle is narrow (about ±40° horizontal and ±30° vertical), the response time is slow (about 50 ms), and the color dispersion is severe. Therefore, it is hard to obtain a good LCD panel by conventional technology. Moreover, rubbing during manufacture will cause electricity discharge and contamination.

To manufacture the LCD panel with wide viewing angle, the prior art has developed many kinds of VA LCD structures. For example, FIG. **1** shows the patterned VA (PVA) type LCD developed by Samsung Company. In FIG. **1**, there are slits **14** on the upper electrode **10** and the lower electrode **12** to form the horizontal electric field around the slits **14**. The curved lines in the FIG. **1** represent the electric potential lines perpendicular to the electric field. Therefore, the arrangement direction of the liquid crystal molecules, perpendicular to the substrate, is turned by the horizontal electric field to form different arrangement directions in different domains.

In addition, Fujitsu Company provides a LCD structure with multiple domains vertical alignment (MVA), which forms protrusions on the upper electrode to provide a pre-lean angle for the liquid crystal molecule to make the liquid crystal molecule form different arrangement directions in the different domains.

The prior art mentioned above can provide LCD with wide viewing angle, but requires additional processes to form the slits or protrusions on the color filter. Moreover, the higher accuracy of the alignment between the upper substrate and the lower substrate is required, and the manufacture process is more complicated.

SUMMARY OF THE INVENTION

In one aspect the present invention provides a thin film transistor liquid crystal display. A first substrate and a second substrate are provided, in which an enclosed space is formed between the first substrate and the second substrate. A liquid crystal layer is filled in the enclosed space. An upper electrode is formed on the inner surface of the first substrate. A lower electrode is formed on the inner surface of the second substrate having a first electrode and a pixel electrode beside the first electrode. The first electrode is coupled to a drain/source of a thin film transistor, and a portion of the pixel electrode is overlapped on the drain/source of the thin film transistor but insulated from the drain/source of the thin film transistor. A plurality of polarizers are formed on the outer surface of the first substrate and the second substrate respectively. In another aspect the present invention provides a TFT-LCD with multiple domains formed by the voltage difference between the lower electrodes, which generates voltage difference by capacitive coupling to control the domain. In addition, the voltage difference is generated between the lower electrodes without adding additional data lines. Therefore, the number of chips needed for driving is decreased and the design of the TFT array is simplified. Moreover, the structure of the upper electrodes does not require modification. Compared with the patterned VA type LCD provided by Samsung Company and the multiple domains vertical aligned type LCD provided by Fujitsu Company, the disclosed manufacture process is simplified.

Preferably, the lower electrode is separated into at least two electrodes, the narrow electrode and the pixel electrode. The pixel electrode can further be separated into more pixel electrodes. In addition, the narrow electrode is coupled to a drain/source of a thin film transistor, and a portion of the pixel electrode is overlapped on the drain/source of the thin film transistor but insulated to the thin film transistor. Therefore, capacitive coupling is preferably generated to make the voltage of the narrow electrode higher than the pixel electrode. Hence, the horizontal electric field is formed between the narrow electrode and the pixel electrode to generate a plurality of domains in a pixel. Additional processing is not required to form slits or protrusions on the color filter and a requirement for high accuracy of alignment between the upper substrate and the lower substrate can be overcome.

BRIEF DESCRIPTION OF THE DRAWINGS

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.

FIG. **1** shows the potential distribution of the conventional PVA type LCD.

FIG. **2**A shows the layout according to the embodiment of the present invention.

FIG. **2**B shows the layout according to another embodiment of the present invention.

FIG. **2**C shows the sectional view of the FIG. **2**A.

FIG. **3** shows the response time of the LCD according to the present invention and the conventional PVA type LCD.

FIG. **4**A shows the structure of the TFT-LCD according to the embodiment of the present invention.

FIG. **4**B shows the potential distribution of the TFT-LCD according to the embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **2**A and FIG. **2**B shows the structures of the pixel according to the present invention. In the FIG. **2**A and FIG. **2**B, there are two examples comprising two and four domains.

First, in FIG. **2**A, the lower electrode of the present embodiment is divided into three separate parts of pixel electrodes **22** and narrow electrode **24** by gaps **20**. The pixel electrodes **22** are electro-floating, and the narrow electrode **24** is connected to the drain **28** through the contact hole **26**. In FIG. **2**B, the lower electrode of the present embodiment is divided into five separate parts of pixel electrodes **23** and narrow electrode **25** by gaps **21**. The four pixel electrodes **23** are electro-floating, and the narrow electrode **25** is connected to the drain **29** through contact hole **27**.

FIG. **2**C shows the sectional view of the FIG. **2**A, which describes the structure of TFT-LCD cell generating voltage difference by capacitive coupling.

The voltage level of the upper electrode **30** having color filter is V_2, and the voltage level of the floating pixel electrode **22** is V_f. The narrow electrode **24** of the lower electrode is connected to the drain **28** of TFT with the voltage of V_1. In addition, C_1 is the capacitance between the pixel electrode **22** and the first dielectric layer **32** (SiN_x for example), where d_1 is the thickness of the first dielectric layer **32**, A_1 is the overlapping area between the first dielectric layer **32** and the pixel electrode **22**, and ϵ is the dielectric constant of the first dielectric layer **32**. The second dielectric layer **34** is liquid crystal layer. C2 is the capacitance between the pixel electrode **22** and the liquid crystal layer, where d_2 is the thickness of the liquid crystal layer, A_2 is the overlapping area between the liquid crystal layer and the pixel elcetrode **22**, and ϵ_2 is the dielectric constant of the liquid crystal layer.

Therefore, the voltage of the pixel electrode is:

$$V_f=(C_1V_1+C_2V_2)/(C_1+C_2) \tag{1}$$

FIG. **3** shows the simulated response time of the LCD according to the present invention and the conventional PVA type LCD. In FIG. **3**, region A represents the response time of the conventional PVA type LCD, and region B represents the response time of the LCD according to the present invention. The symbol '▲' represents the response time while the voltage of the upper electrode is zero, and the voltage of the pixel electrode is 3V. The symbol '■' represents the response time while the voltage of the upper electrode is zero, and the voltage of the pixel electrode is 4V. The symbol '◆' represents the response time while the voltage of the upper electrode is zero, and the voltage of the pixel electrode is 5V. The response time of the present invention is obviously decreasing when the voltage of the narrow electrode is higher than the pixel electrode approximately 10%, which is better than the prior art.

The condition mentioned above can be expressed with the following equation:

$$V_f-V_2<0.9(V_1-V_2) \tag{2}$$

According to equations (1) and (2), we can obtain equation (3):

$$C_1/C_2<9 \tag{3}$$

According to the equation of capacitance:

$$C=\epsilon A/d$$

We can obtain equation (4):

$$\epsilon_1A_1d_2/\epsilon_2A_2d_1<9 \tag{4}$$

Therefore, if the condition of equation (4) is satisfied, there is sufficient voltage difference between the pixel electrode **22** and the narrow electrode **24** to obtain shorter response time than PVA type LCD.

FIG. **4**A shows the structure of the TFT-LCD according to the embodiment of the present invention. The TFT-LCD according to the embodiment of the present invention an upper substrate **40**, a lower substrate **50**, a liquid crystal layer **60**, an upper electrode **42**, a lower electrode, and polarizers **70**.

An enclosed space is formed between the upper substrate **40** and the lower substrate **50**. The liquid crystal layer **60** is filled in the enclosed space. The upper electrode **42** is formed on the inner surface of the upper substrate **40**. The lower electrode is formed on the inner surface of the lower substrate. The lower substrate comprises a narrow electrode **52** and at least one pixel electrode **54** beside the narrow electrode **52**.

FIG. **4**B shows the potential distribution of the TFT-LCD according to the embodiment of the present invention. According to the present embodiment, the upper electrode **42** is a pack electrode and connected to ground, and the lower electrode is divided into two pixel electrodes **54** and one narrow electrode **52**. The voltage of the narrow electrode **52** is higher than the pixel electrode **54** from 5% to 200%. In addition, the narrow electrode **52** is coupled to a drain/source of a thin film transistor, and a portion of the pixel electrode **54** is overlapped on the drain/source of the thin film transistor but insulated to the drain/source of the thin film transistor. A plurality of polarizers is formed on the outer surface of the upper substrate **40** and the lower substrate **50** respectively.

In FIG. **4**B, the horizontal electric field is formed between the narrow electrode **52** and the pixel electrode **54**, the curved lines in the FIG. **4**B represent the electric potential lines. The direction of the electric field of the present invention is similar to the conventional PVA type LCD, so the director of the liquid crystal molecule is similar to the conventional PVA type LCD. However, the present invention doesn't have to form additional slits on the upper electrode.

In the present invention, the lower electrode is divided into at least two pixel electrodes **54** and one narrow electrode **52**. There is no limitation on the shape of the narrow electrode, so the shape of the narrow electrode can be a straight line or a curved line. The pieces, shape and size of the pixel electrode are not limited, and can be even or odd. The size of each domain is dependent on the design, and the size of gap is designed to generate sufficient horizontal electric field. Further, the liquid crystal layer according to the present inventiton is a negative type liquid crystal layer.

The structure of the present invention further can comprise compensative flakes, color filters, and reflector in different application. In addition, the structure of the present invention further comprises TFT and peripheral circuits.

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 were chosen and described to provide the best 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 thin film transistor liquid crystal display, comprising:

a first substrate and a second substrate, in which an enclosed space is formed between the first substrate and the second substrate;

a liquid crystal layer filled in the enclosed space;

an upper electrode formed on the inner surface of the first substrate;

a lower electrode formed on the inner surface of the second substrate having a first electrode and a pixel electrode beside the first electrode, wherein the first electrode is coupled to a drain/source of a thin film transistor, and a portion of the pixel electrode is overlapped on the drain/source of the thin film transistor but insulated from the drain/source of the thin film transistor; and

a plurality of polarizers formed on the outer surface of the first substrate and the second substrate respectively.

2. The thin film transistor liquid crystal display as claimed in claim **1**, wherein the liquid crystal layer is a negative type liquid crystal layer.

3. The thin film transistor liquid crystal display as claimed in claim **1**, wherein the voltage level of the first electrode is higher than the pixel electrode from 5% to 200%.

4. The thin film transistor liquid crystal display as claimed in claim **1**, wherein the first electrode is coupled to the drain of the thin film transistor.

5. The thin film transistor liquid crystal display as claimed in claim **1**, wherein the pixel electrode is electro-floating.

6. The thin film transistor liquid crystal display as claimed in claim **1**, wherein the voltage level of the pixel electrode is generated by capacitive coupling.

7. The thin film transistor liquid crystal display as claimed in claim **1**, wherein the first electrode is relatively narrower than the pixel electrode.

* * * * *

专利名称(译)	薄膜晶体管液晶显示器，其中下电极包括第一电极和像素电极		
公开(公告)号	US6680771	公开(公告)日	2004-01-20
申请号	US10/071062	申请日	2002-02-07
[标]申请(专利权)人(译)	友达光电股份有限公司		
申请(专利权)人(译)	友达光电.		
当前申请(专利权)人(译)	友达光电.		
[标]发明人	YU JIAN SHEN CHANG WEI CHIH		
发明人	YU, JIAN-SHEN CHANG, WEI-CHIH		
IPC分类号	G02F1/1333 G02F1/13 G02F1/139 G02F1/1343 G02F1/1368 G02F1/136 G02F1/133		
CPC分类号	G02F1/133707 G02F1/134336 G02F1/1393 G02F2001/134345		
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优先权	090103234 2001-02-14 TW		
其他公开文献	US20020109813A1		
外部链接	Espacenet USPTO		

摘要(译)

薄膜晶体管液晶显示器在下电极之间产生电压差，然后通过电压差控制产生域。下电极分为窄电极和像素电极。像素电极进一步分为多个像素电极。窄电极耦合到薄膜晶体管的漏极或源极，并且像素电极的一部分重叠在薄膜晶体管的漏极/源极上，但绝缘到薄膜晶体管的漏极/源极以产生电容耦合使窄电极的电压电平超过像素电极的电压电平。因此，形成水平电场以在信号像素中产生多个域。