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(54) **IN-PLANE SWITCHING MODE LIQUID CRYSTAL DISPLAY DEVICE**

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(30) **Foreign Application Priority Data**

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Publication Classification

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(52) **U.S. Cl.** **349/141**; 349/39; 349/139

(57) **ABSTRACT**

An in-plane switching mode liquid crystal display device comprises a substrate, a pixel region, a common bus line, a thin film transistor, a data electrode, a passivation layer over the data electrode and the thin film transistor, and a common electrode. The pixel region lies on the substrate. The common bus line is aligned in the pixel region. The thin film transistor is coupled to the pixel region and the pixel regions comprises a gate electrode and a gate insulator having a portion overlying the gate electrode. The data electrode lies over the gate insulator and has a portion overlying the common bus line to form a first storage capacitor. The passivation layer overlies the data electrode and the thin film transistor. The common electrode overlies the passivation layer and has a portion overlying the data electrode to form a second storage capacitor.

FIG.1a
PRIOR ART

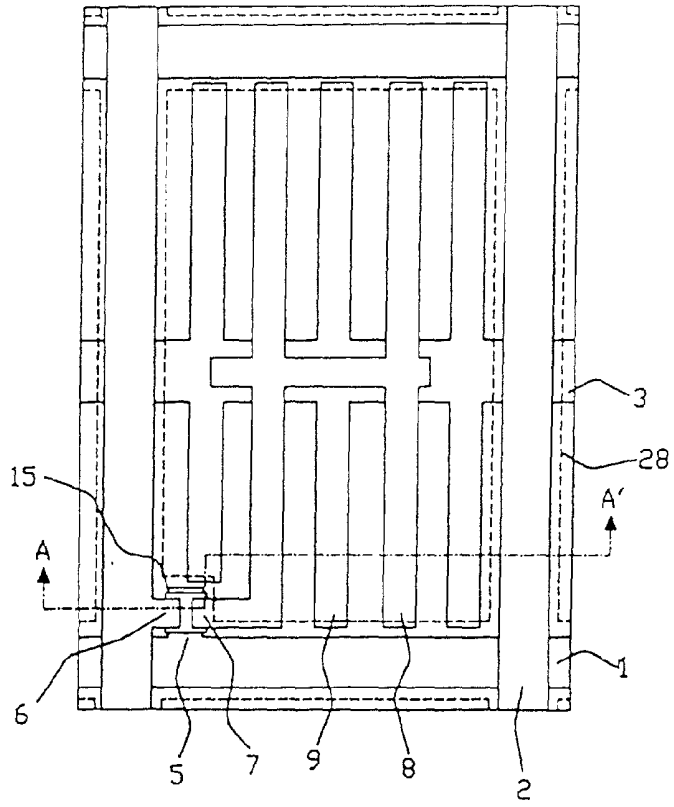


FIG.1b
PRIOR ART

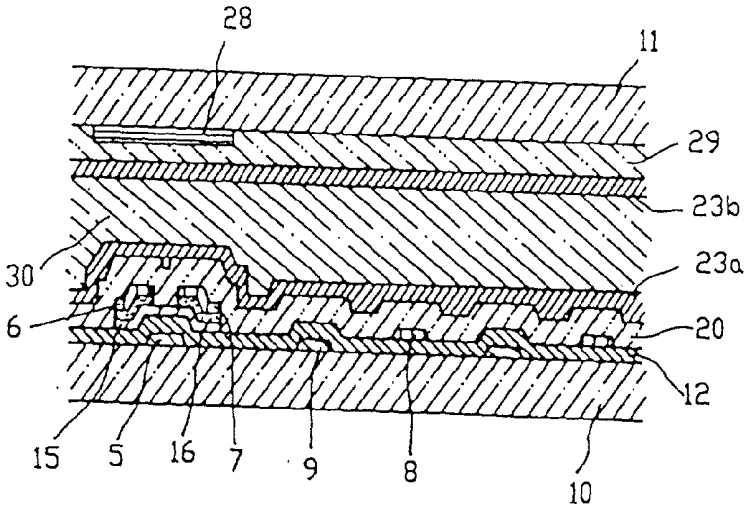


FIG.2

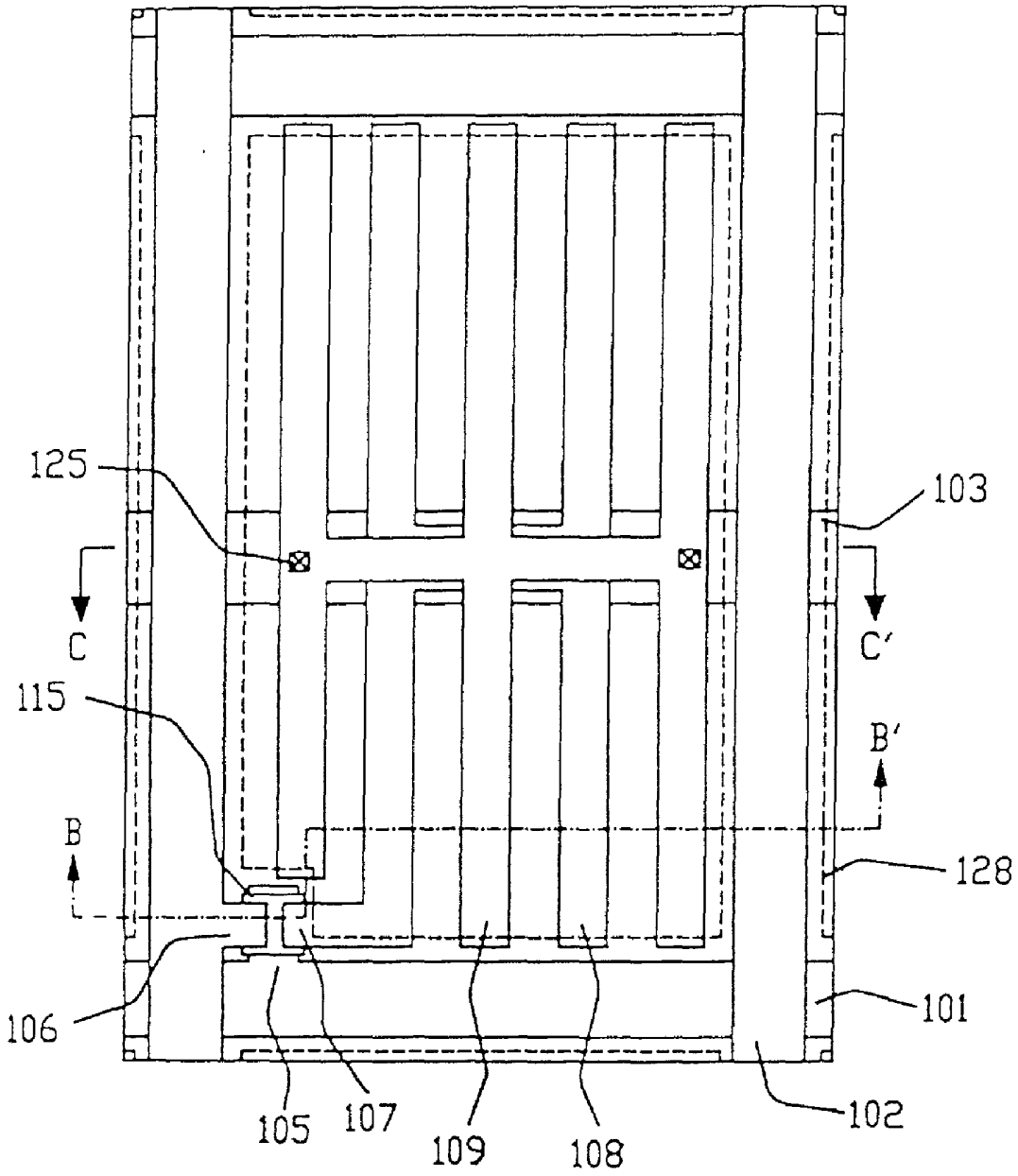


FIG.3a

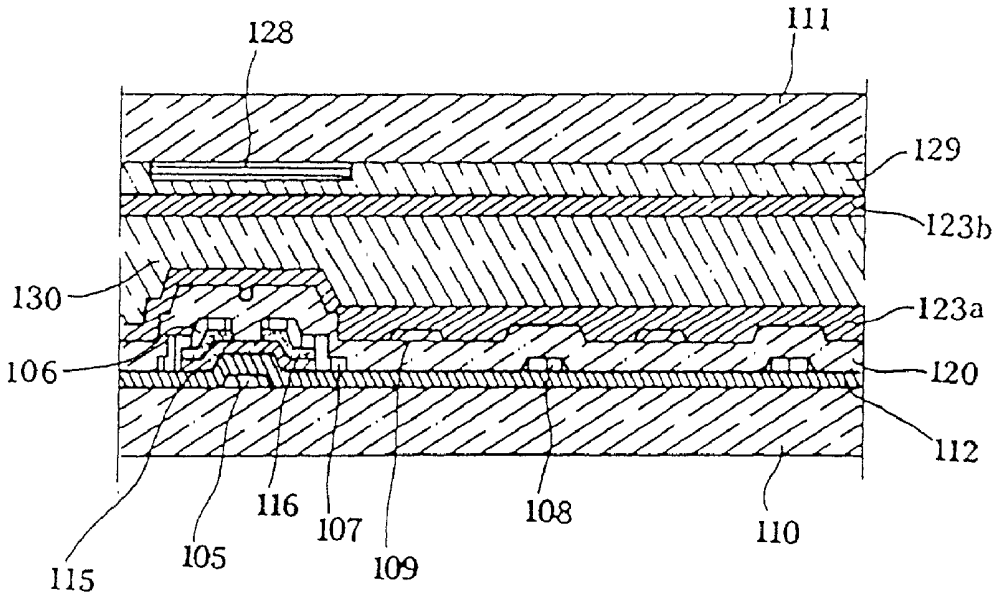

128
111
129
123b
130
123a
106
120
112
116
107
108
110
115
105
109

FIG.3b

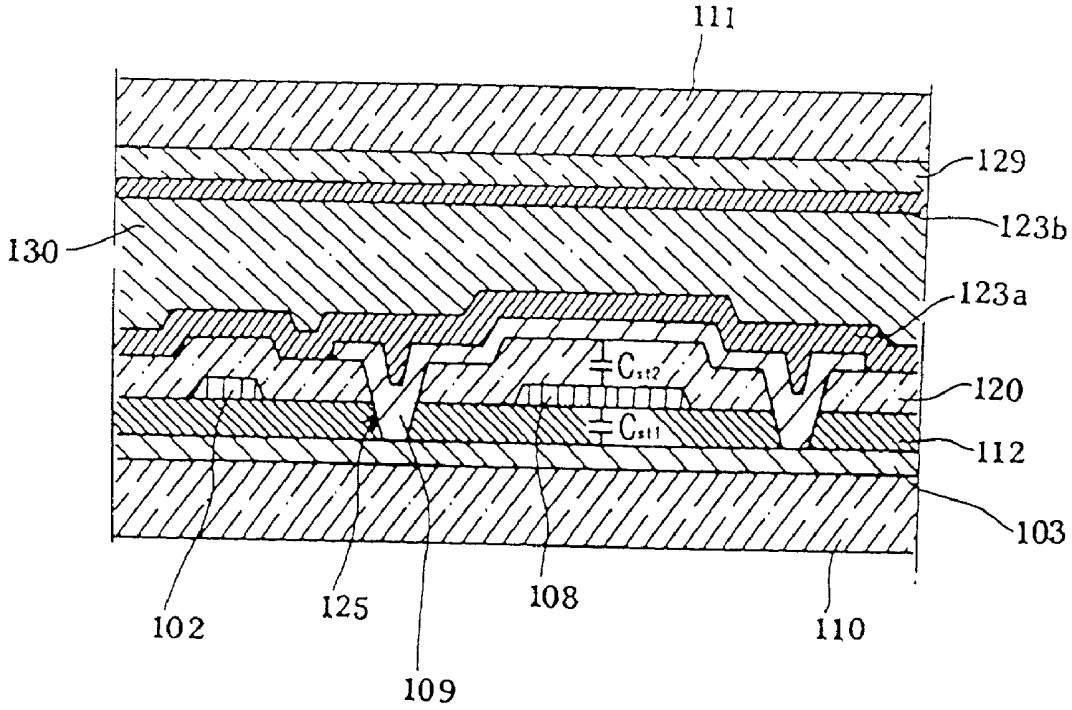

111
129
130
123b
123a
C_{st2}
120
C_{st1}
112
103
102
125
108
110
109

FIG.4

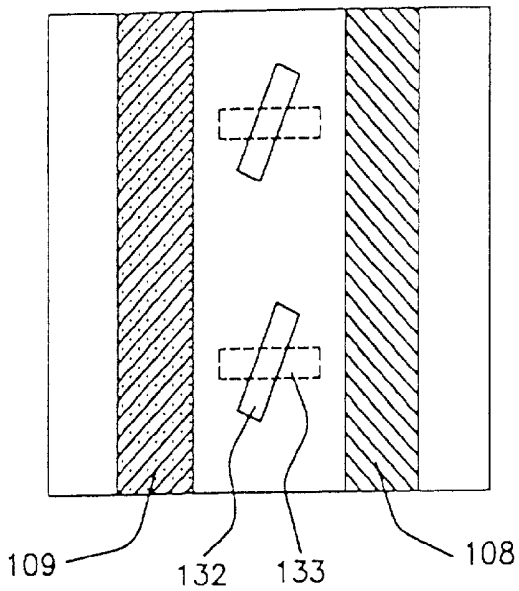


FIG.5

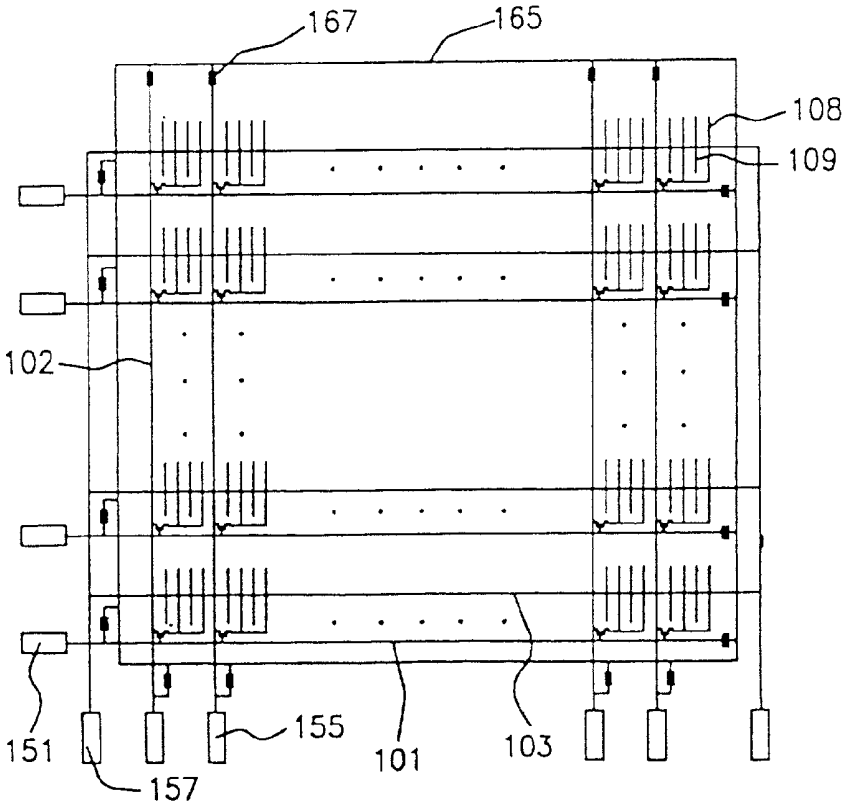


FIG.6a

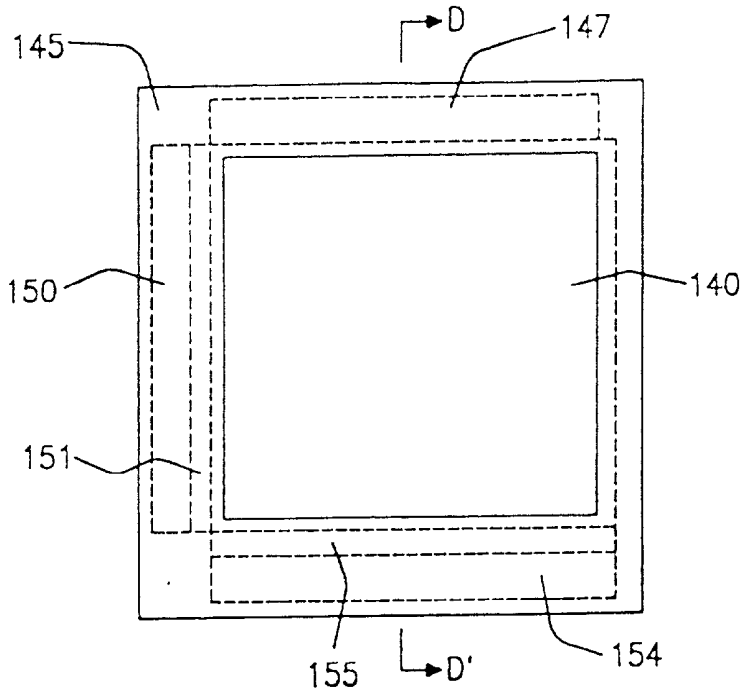


FIG.6b

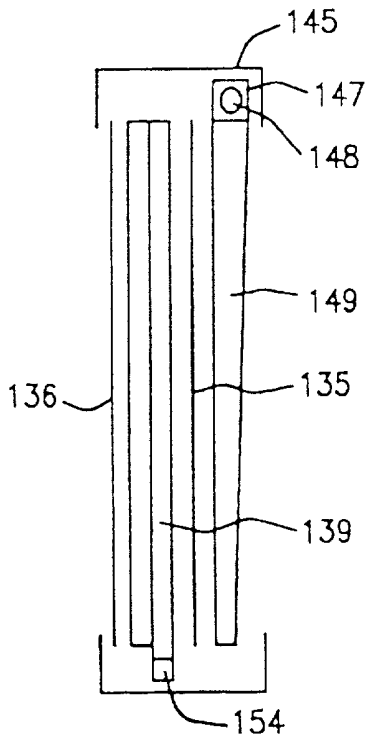


FIG.7a

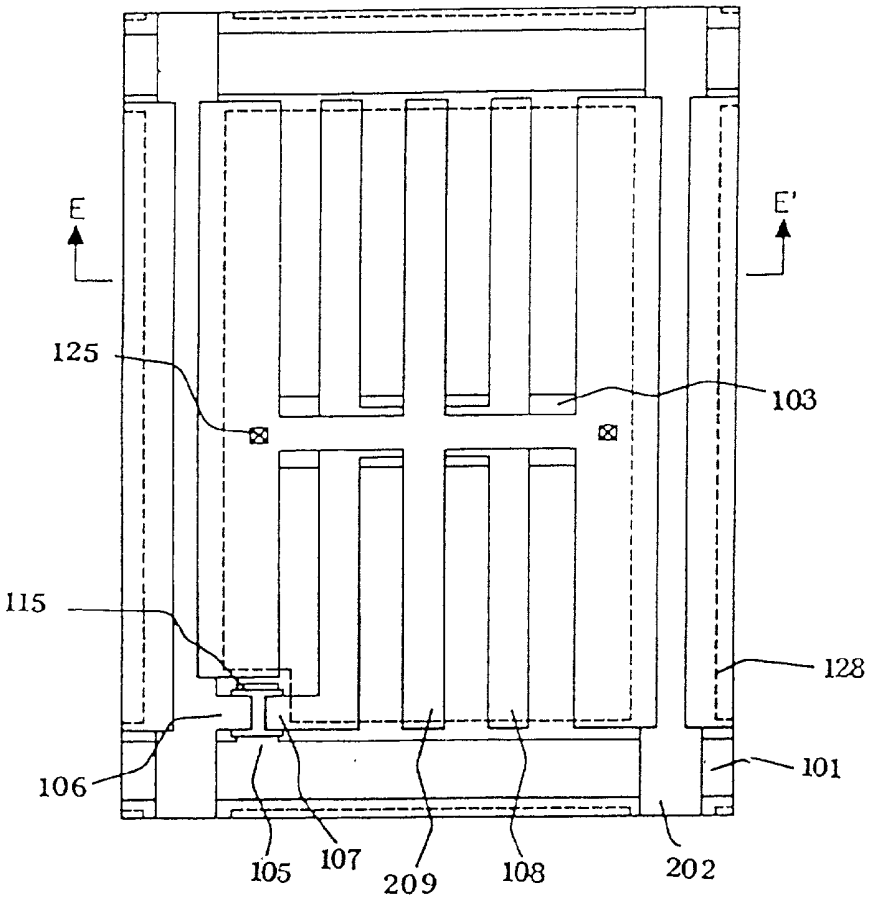
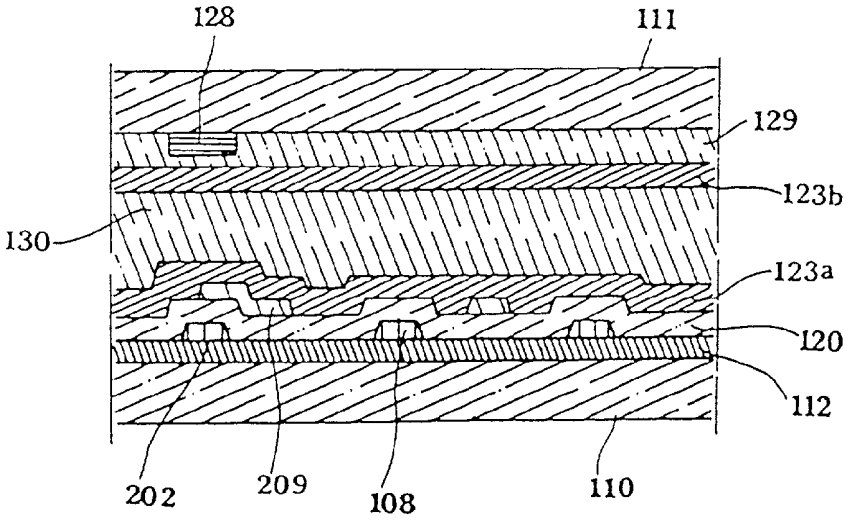

E
E'
125
103
115
128
101
106
105
107
209
108
202

FIG.7b


128
111
129
123b
130
123a
120
112
202
209
108
110

IN-PLANE SWITCHING MODE LIQUID CRYSTAL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

[0001] A. Field of the Invention

[0002] The present invention relates to a liquid crystal display device, and more particularly to an in-plane switching mode liquid crystal display device.

[0003] B. Description of the Related Art

[0004] Recently, the thin film transistor liquid crystal display device (TFT LCD) has been used as a display device of many applications such as a portable television and a notebook computer, but such TFT LCD has a small viewing angle.

[0005] In order to solve this problem, twisted nematic LCDs having optical compensation plates and a multi-domain LCD, and so forth, have been introduced. In these LCDs, however, the color of the image is shifted because the contrast ratio depends on the viewing angle direction.

[0006] For a wide viewing angle, an in-plane switching mode LCD is disclosed, for example, in JAPAN DISPLAY 92 p547, Japanese Patent Unexamined Publication No. 7-36058, Japanese Patent Unexamined Publication No. 7-225388, and ASIA DISPLAY 95 P707.

[0007] **FIG. 1***a* and **FIG. 1***b* are respectively plane and sectional views showing the conventional in-plane switching mode liquid crystal display device (IPS mode LCD). **FIG. 1***b* is a sectional view taken along line A-A' of **FIG. 1***a*. As shown in these figures, a gate bus line **1** and a data bus line **2** are formed on a first substrate **10**, defining a pixel. Although only one pixel is drawn in the figures, a liquid crystal display device generally has a plurality of pixels. A common bus line **3** is aligned in the pixel, being parallel to gate bus line **1**. A thin film transistor (TFT) is disposed at the cross of gate and data bus lines **1** and **2**. As shown in **FIG. 1***b*, the TFT comprises a gate electrode **5**, a gate insulator **12**, a semiconductor layer **15**, an ohmic contact layer **16** and source/drain electrodes **6** and **7**. In the pixel, a data electrode **8** and a common electrode **9** are formed parallel to data bus line **2**. A portion of data electrode **8** which overlaps common bus line **3** is formed to obtain a storage capacitor which functions as maintaining a grey level voltage applied into data electrode **8**. Common electrode **9** is connected to common bus line **3**. Data electrode **8** is formed on gate insulator **12** and is connected to drain electrode **7**. The TFT, data electrode **8** and gate insulator **12** are covered with a passivation layer **20**. Thereon, a first alignment layer **23***a* is coated to impart an alignment direction.

[0008] On a second substrate **11**, a black mask **28** is formed to prevent a leakage of light through the regions of the TFT and gate, data and common bus lines **1**, **2**, and **3**. Thereon, a color filter layer **29** and a second alignment layer **23***b* are formed. Between first and second substrates **10** and **11**, a liquid crystal layer **30** is formed.

[0009] When a voltage is applied to the conventional IPS mode LCD, an electric field parallel to substrates **10** and **11** is generated between data and common electrodes **8** and **9**. Liquid crystal molecules in the pixel are rotated according to the electric field, controlling the amount of light passing through liquid crystal layer **30**.

[0010] However, the conventional IPS mode LCD has the following problems. First, because the area for storage capacitor occupies quite a portion of the pixel region, and the data and common electrodes are made of opaque metals, the aperture ratio is lowered. Second, because the electric field applied to the LC layer is weakened by both gate insulator **12** and passivation layer **20** formed over two electrodes **8** and **9**, the driving speed of the LC molecules is decreased, and consequently the driving voltage is increased. Third, because data bus line **2** should be apart from the pixel region to the extent of not generating the crosstalk problem, the pixel region is decreased, thereby lowering the aperture ratio.

SUMMARY OF THE INVENTION

[0011] An object of the present invention is to provide an in-plane switching mode liquid crystal display device having a low driving voltage.

[0012] Another object of the present invention is to provide an in-plane switching mode liquid crystal display device having an improved aperture ratio.

[0013] Additional objects and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims.

[0014] To achieve the objects and in accordance with the purpose of the invention, as embodied and broadly described herein, the invention comprises: a substrate; a common bus line over the substrate; a first insulator over the common bus line; a first electrode over the first insulator, the first electrode at least partially covering the common bus line to form a first storage capacitor between the first electrode and the common bus line; a second insulator over the first electrode; and a second electrode over the second insulator, the second electrode at least partially covering the first electrode to form a second storage capacitor between the first and second electrodes.

[0015] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description, serve to explain the principles of the invention.

[0017] In the figures:

[0018] **FIG. 1***a* and **FIG. 1***b* are respectively plane and sectional views of a conventional in-plane switching mode liquid crystal display device;

[0019] **FIG. 2** is a plane view showing a first embodiment according to the present invention;

[0020] **FIG. 3***a* and **FIG. 3***b* are sectional views of **FIG. 2**;

[0021] **FIG. 4** is a view showing the operation of liquid crystal liquid crystal molecules in the present invention;

[0022] **FIG. 5** is a view showing the TFT array structure of an implementation consistent with the present invention;

[0023] **FIG. 6***a* and **FIG. 6***b* are respectively plane and sectional views showing the structure of the IPS mode LCD according to the present invention; and

[0024] **FIG. 7***a* and **FIG. 7***b* are respectively plane and sectional views showing a second embodiment according to the present invention.

DETAIL DESCRIPTION OF THE INVENTION

[0025] Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0026] In an in-plane switching mode liquid crystal display device implemented according to the present invention, the common electrode is formed over the passivation layer, and the passivation layer and the gate insulator do not weaken the electric field applied into the liquid crystal layer. Consequently, the driving voltage may be lowered. Further, because the area for storage capacitor can be decreased, the aperture ratio is improved.

[0027] Moreover, the common electrode may be formed to overlap the data bus lines to remove the crosstalk problem. In this case, because the pixel region can be enlarged, the aperture ratio becomes much more improved. In order to prevent signal delay in the data bus lines which is generated by being overlapped with the common electrode, the data bus lines is formed of highly conductive metal layers such as a Mo metal layer, Mo/Al/Mo triple metal layers, or Cr/Al/Cr triple metal layers.

[0028] Furthermore, the common electrode may be formed of a transparent electrode such as indium tin oxide in order to lower contacting electric resistance between pads and driving circuits as well as to improve the aperture ratio.

[0029] **FIG. 2**, **FIG. 3***a* and **FIG. 3***b* are views showing a first embodiment according to the present invention. **FIG. 3***a* and **FIG. 3***b* are respectively sectional views taken along line B-B' and line C-C' of the **FIG. 2**. As shown in these figures, gate and data bus lines **101** and **102** are formed on a first substrate **110**, defining a pixel. Although only one pixel is drawn in these figures, a liquid crystal display device generally has a plurality of pixels. In the pixel, a common bus line **103** is formed parallel to the data bus line **102**. At the cross of the gate and data bus lines **101** and **102**, a thin film transistor (TFT) is formed. In the pixel, data and common electrodes **108** and **109** are disposed parallel to data bus line **102**. As in the conventional IPS mode LCD, data electrode **108** has a portion overlapping common bus line **103** for obtaining a first storage capacitor (C_{st1}) as shown in **FIG. 3***b*. In addition, common electrode **109** has a portion overlapping data electrode **108** for obtaining a second storage capacitor (C_{st2}). Common electrode **109** is connected to common bus line **103** through a hole **125**.

[0030] As shown in **FIG. 3***a*, the TFT comprises a gate electrode **105**, a gate insulator **112**, a semiconductor layer **115**, an ohmic contact layer **116**, and source/drain electrodes **106** and **107**. Gate electrode **105** is formed by patterning double metal layers (Mo/Al) composed of an Al layer having a thickness of 2000 Å and a Mo layer having a thickness of 1000 Å, where the double metal layers are deposited by a sputtering method. Gate and common bus lines **101** and **103** are formed together with gate electrode **105**. Gate insulator **112** is formed thereon by depositing an inorganic insulating layer such as silicon nitride having a thickness of 4000 Å by a CVD (chemical vapor deposition) method. Semiconductor layer **115** and ohmic contact layer **116** are formed by depositing and etching an amorphous silicon (a-Si) layer having a thickness of 1700 Å and an n^+a-Si layer having a thickness of 300 Å. Data bus line **102** and source/drain electrodes **106** and **107** are formed by etching a Cr metal layer having a thickness of 1500 Å deposited by sputtering method. As shown in **FIG. 2**, gate and source electrodes **105** and **106** are connected to gate and data bus lines **101** and **102** respectively, and drain electrode **107** is connected to data electrode **108**.

[0031] The TFT, gate bus line **101** and gate insulator **112** are covered with a passivation layer **120** such as silicon oxide and silicon nitride having a thickness of 2000 Å. On passivation layer **120**, common electrode **109** is formed by depositing and etching a transparent conducting layer such as indium tin oxide (ITO) having a thickness of 500 Å.

[0032] Over common electrode **109** and passivation layer **120**, a first alignment layer **123***a* is formed by coating polyamide or polyimide or photo-alignment materials. The polyamide or polyimide alignment layer may be rubbed to impart an alignment direction. On the other hand, the photo-alignment layer such as polyvinylcinnamate (PVCN) or polysiloxane based materials is exposed to an ultra violet light to impart the alignment direction.

[0033] As shown in **FIG. 3***b*, common electrode **109** is connected to common bus line **103** through hole **125** formed in gate insulator **112** and passivation layer **120**. As shown in **FIG. 2** and **FIG. 3***b*, data and common electrodes **108** and **109** have portions for first and second storage capacitors (C_{st1}, C_{st2}). Accordingly, the total storage capacitor (C_{st}) in the present invention becomes the sum of the first and second storage capacitors (C_{st1}, C_{st2}). The storage capacitor (C_{st}) is double the conventional storage capacitor (C_{st1}), so that the area for storage capacitor can be reduced to half the conventional area, thereby improving the aperture ratio.

[0034] As shown in **FIGS. 3***a* and **3***b*, on a second substrate **111**, a black mask **128** and a color filter layer **129** are formed. An overcoat layer may be formed thereon for the flatness and stability of the surface thereof. Black mask **128** prevents a leakage of light through the regions of TFT and gate, data and common bus lines **101**, **102**, and **103**. Black mask **128** is made of a Cr or a CrOx metal layer having a thickness of 0.1 μm and a width of 10 μm or a resin. Color filter layer **129** has one of R, G, and B color filter elements in each pixel. On color filter layer **129**, a second alignment layer **123***b* is formed by coating polyamide or polyimide or photo-alignment materials such as PVCN or polysiloxane based materials. Second alignment layer **123***b* is rubbed or exposed to UV light to impart an alignment direction. A liquid crystal layer **130** is formed between the two substrates **110** and **111** by injecting liquid crystal in a vacuum state.

[0035] **FIG. 4** is a view showing the operation of liquid crystal molecules in the IPS mode LCD according to the

present invention. When a voltage is applied to the device, electric field parallel to the substrates is generated between common and data electrodes **108** and **109**. Therefore, liquid crystal molecules **132** are rotated clockwise according to the electric field. In this figure, reference number **133** indicates the liquid crystal molecules after applying the voltage.

[**0036**] In the first embodiment, passivation layer **120** and gate insulator **112** do not absorb the electric field applied to liquid crystal layer **130** because common electrode **109** is disposed above two insulating layers **112** and **120**. Accordingly, the driving voltage can be lowered. Further, because the common electrode is formed out of a transparent conducting layer such as ITO, the aperture ratio is improved. Furthermore, because the areas for storage capacitor can be decreased, the aperture ratio is much more improved.

[**0037**] **FIG. 5** is a view showing the TFT array structure of the present invention. Gate and data bus lines **101** and **102** are connected to gate and data driving circuits through gate and data pads **151** and **155** respectively. Gate and data bus lines **101** and **102** are connected to a grounding wiring **165** through an electrostatic discharging circuit **167** composed of TFT. Also, common bus line **103** is grounded through common pad **157**.

[**0038**] Although not illustrated in the figure, gate, data and common pads **151**, **155** and **157** are made of first, second and third metal layers. The first metal layer is formed of Mo/Al double metal layers as gate electrode **105** and common bus line **103** as shown in **FIG. 2**. The second metal layer is formed of Cr as source and drain electrodes **106** and **107**. The third metal layer is formed of ITO as common electrode **109**. In order to connect the pads to the driving circuits, it is necessary to etch the gate insulator or the passivation layer in the pad region. The two insulating layers in the pad region are etched when hole **125** is formed. In the prior art, an oxide layer is generated on the pads by the exposure to the air, causing a problem that the contacting electric resistance is increased when connecting the pads to the driving circuits. However, in this embodiment, because the third metal layer of the pads is made of ITO, the problem is not generated.

[**0039**] **FIG. 6***a* and **FIG. 6***b* are plane and sectional views showing the structure of the in-plane switching mode LCD according to the present invention. **FIG. 6***b* is a sectional view taken along line D-D' of **FIG. 6***a*. As shown in these figures, gate and data driving circuits **150** and **154** are disposed in a frame **145** outside display region **140**. Gate and data driving circuits **150** and **154** are connected to gate and data bus lines **101** and **102** (shown in **FIG. 5**) through gate and data pads **151** and **155** respectively. A back light housing **147** is disposed on the upper side of frame **145**. In backlight housing **147**, a backlight **148** is disposed to project a light into a liquid crystal panel **139** through a light pipe **149**. Between light pipe **149** and liquid crystal panel **139**, a polarizer **135** is disposed to polarize the light linearly. An analyzer **136** is disposed on the front of panel **139**.

[**0040**] **FIG. 7***a* and **FIG. 7***b* are respectively plane and sectional views showing a second embodiment of the present invention. **FIG. 7***b* is a sectional view taken along line E-E' of **FIG. 7***a*. As shown in these figures, this embodiment differs from the first embodiment in that a common electrode **209** overlaps a data bus line **202**. The parts of the second embodiment that are the same as the first embodiment are indicated by the same reference number as the first embodiment. In the second embodiment, although common electrode **209** can be made of opaque metals, it is preferable to form common electrode **209** out of a transparent conducting metal such as ITO in order to improve the aperture ratio. In general, because data bus line **202** should be separated from the pixel region to the extent of avoiding the crosstalk problem, the aperture ratio is lowered. But in this embodiment, because the electric effect by data bus line **202** is shielded by common electrode **209**, the crosstalk problem can be eliminated.

[**0041**] Accordingly, the pixel region can be enlarged improving the aperture ratio. But, a parasitic capacitor may be formed between common electrode **209** and data bus line **202**, causing the signal delay in data bus line **202**. This signal delay problem can be removed by forming data bus line **202** out of low resistance metal layers such as Mo metal layer, Mo/Al/Mo triple metal layers or Cr/Al/Cr triple metal layers.

[**0042**] In the in-plane switching mode liquid crystal display device according to the present invention, because the common electrode is formed on the passivation layer, the passivation layer and the gate insulator do not weaken the electric field applied into the liquid crystal layer. Consequently, the driving voltage may be lowered. Further, because the common electrode overlaps the data bus line to remove the crosstalk problem, the pixel region can be enlarged, thereby improving the aperture ratio as well as the display quality. Furthermore, because the area for storage capacitor is decreased, the aperture ratio is much more improved.

[**0043**] Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. A liquid crystal display device, comprising:

a substrate;

a common bus line over said substrate;

a first insulator over said common bus line;

a first electrode over said first insulator, said first electrode at least partially covering said common bus line to form a first storage capacitor between said first electrode and said common bus line;

a second insulator over said first electrode; and

a second electrode over said second insulator, said second electrode at least partially covering said first electrode to form a second storage capacitor between said first and second electrodes.

2. The device according to claim 1, wherein said second electrode is conductively coupled to said common bus line.

3. The device according to claim 1, wherein said second electrode is conductively coupled to said common bus line through a hole in said first and second insulators.

4. The device according to claim 1, wherein said first electrode includes a data electrode.

5. The device according to claim 1, wherein said first insulator includes a gate insulator.

6. The device according to claim 1, wherein said second electrode includes a common electrode.

7. The device according to claim 1, wherein said second insulator includes a passivation layer.

8. The device according to claim 1, further comprising:

a plurality of gate and data bus lines aligned in said substrate to define a plurality of pixel regions, wherein said second electrode at least partially overlies said data bus lines.

9. The device according to claim 1, further comprising an alignment layer over said second electrode.

10. The device according to claim 6, wherein said common electrode includes a transparent conductive material.

11. The device according to claim 6, wherein said common electrode includes indium tin oxide.

12. The device according to claim 8, wherein said data bus lines include a highly conductive metal.

13. The device according to claim 8, wherein said data bus lines include one of a Mo metal layer, Mo/Al/Mo triple metal layers, or Cr/Al/Cr triple metal layers.

14. The device according to claim 9, wherein said alignment layer includes one of polyimide or polyamide, or polyvinylcinnamate or polysiloxane based materials.

15. A liquid crystal display device, comprising:

a substrate;

a plurality of gate and data bus lines over the substrate, defining a plurality of pixel regions;

a thin film transistor coupled to each of said pixel regions and respective gate and data bus lines;

a passivation layer over said thin film transistor and at least partially covering said data bus line; and

a common electrode over said passivation layer and at least partially covering said data bus line.

16. The device according to claim 15, wherein said data bus line includes a highly conductive metal.

17. The device according to claim 15, wherein said data bus line includes one of a Mo metal layer, Mo/Al/Mo triple metal layers, or Cr/Al/Cr triple metal layers.

18. A liquid crystal display device, comprising:

a substrate;

a common bus line over said substrate;

a first insulator over said common bus line;

a data electrode over said first insulator;

a second insulator over said data electrode, and

a common electrode over said second insulator and coupled to said common bus line.

19. The device according to claim 18, wherein said common electrode is conductively coupled to said common bus line through a hole in said first and second insulators.

* * * * *

专利名称(译)	面内切换模式液晶显示装置		
公开(公告)号	US20010002146A1	公开(公告)日	2001-05-31
申请号	US09/752441	申请日	2001-01-03
申请(专利权)人(译)	LG电子株式会社.		
当前申请(专利权)人(译)	LG DISPLAY CO.，LTD.		
[标]发明人	KOMATSU HIROSHI		
发明人	KOMATSU, HIROSHI		
IPC分类号	G02F1/1343 G02F1/1362		
CPC分类号	G02F1/134363 G02F1/136213		
优先权	1019970032462 1997-07-12 KR		
其他公开文献	US6384888		
外部链接	Espacenet USPTO		

摘要(译)

面内切换模式液晶显示装置包括基板，像素区域，公共总线，薄膜晶体管，数据电极，数据电极和薄膜晶体管上方的钝化层，以及公共电极。像素区域位于基板上。公共总线在像素区域中对齐。薄膜晶体管耦合到像素区域，并且像素区域包括栅电极和栅极绝缘体，栅极绝缘体具有覆盖栅电极的部分。数据电极位于栅极绝缘体上方并且具有覆盖公共总线的部分以形成第一存储电容器。钝化层覆盖数据电极和薄膜晶体管。公共电极覆盖在钝化层上并且具有覆盖数据电极的部分以形成第二存储电容器。

FIG.1a
PRIOR ART

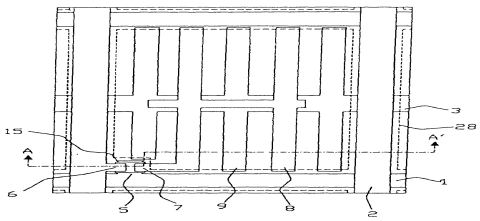


FIG.1b
PRIOR ART