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(54) IN-PLANE SWITCHING LCD PANEL

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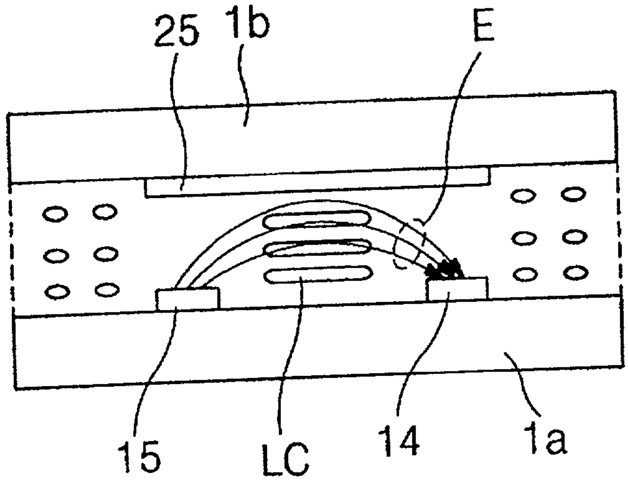
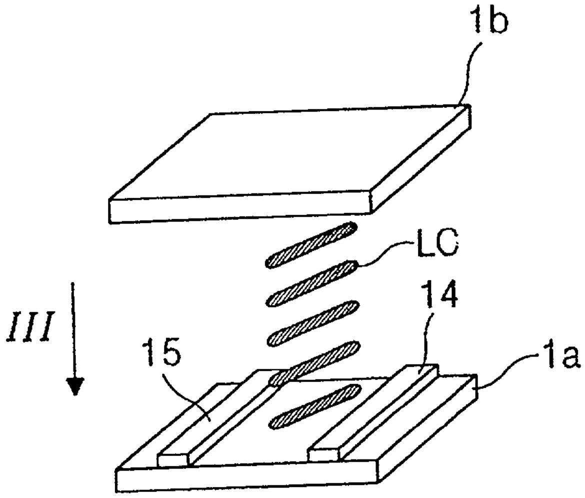
(57) **ABSTRACT**

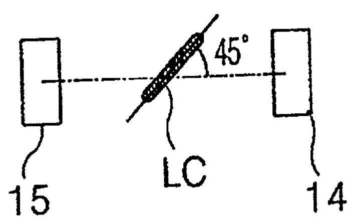
An array substrate of a liquid crystal display panel includes a substrate; a thin film transistor on the substrate; a pixel electrode having a plurality of first tips, the first tips being formed at at least one edge of the pixel electrode; and a common electrode having a plurality of second tips, the second tips being formed at at least one edge of the pixel electrode and the common electrode being parallel with the pixel electrodes.



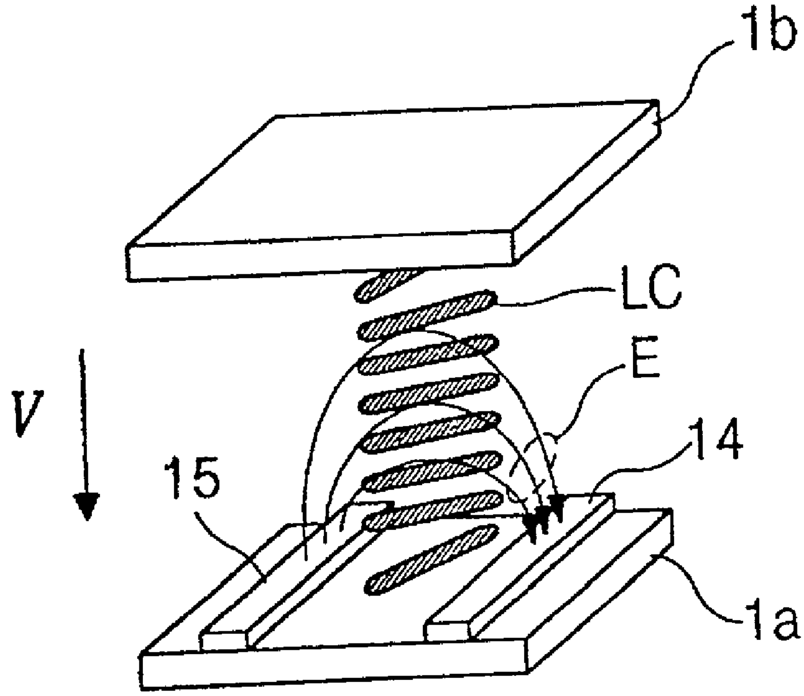
(related art)
FIG. 1



(related art)
FIG. 2

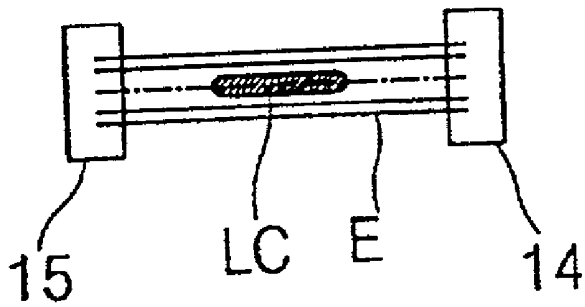


(related art)
FIG. 3



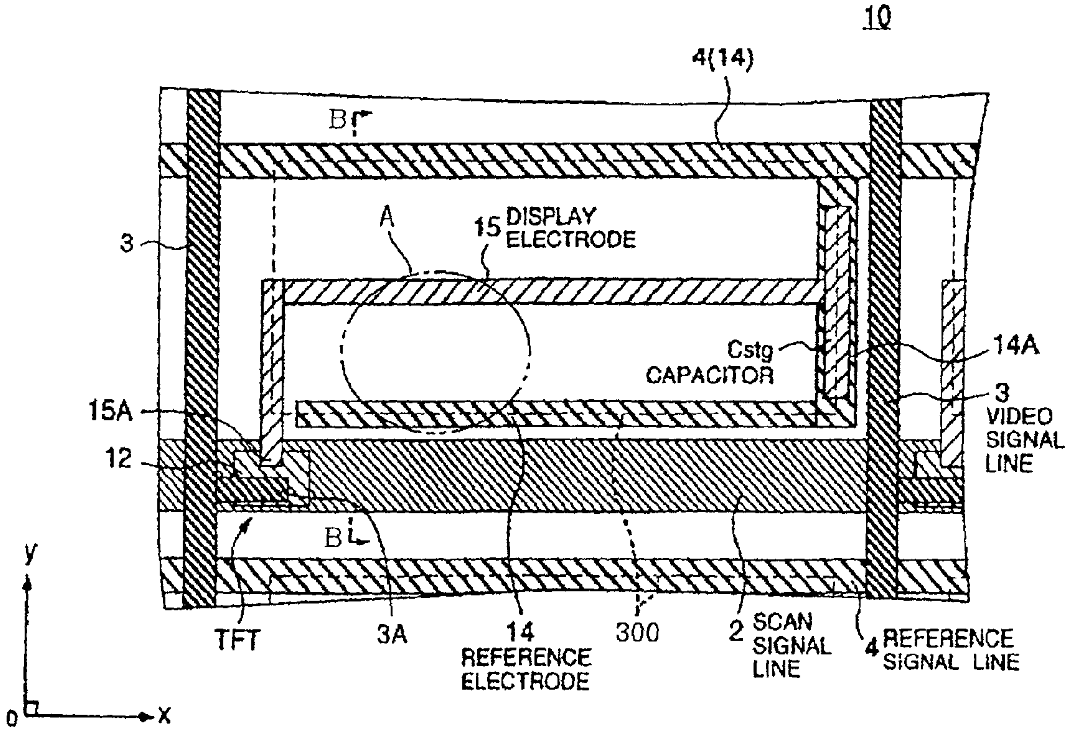
(related art)

FIG. 4



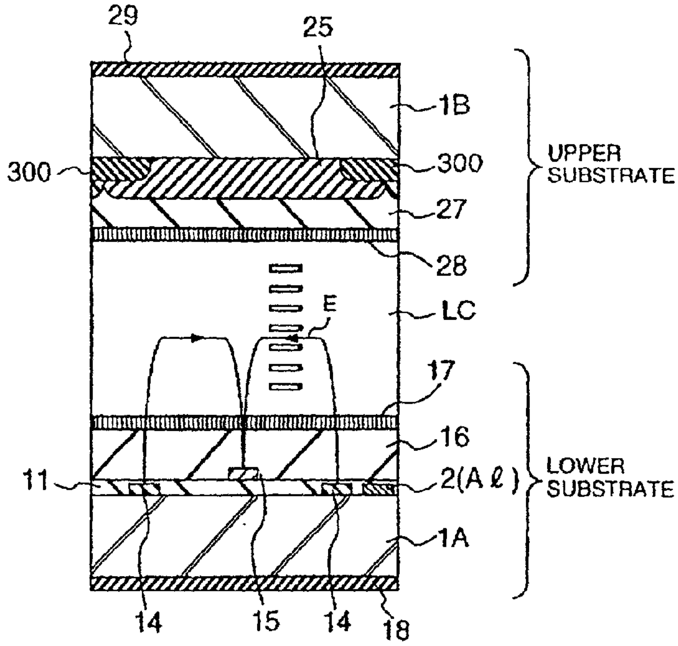
(related art)

FIG. 5



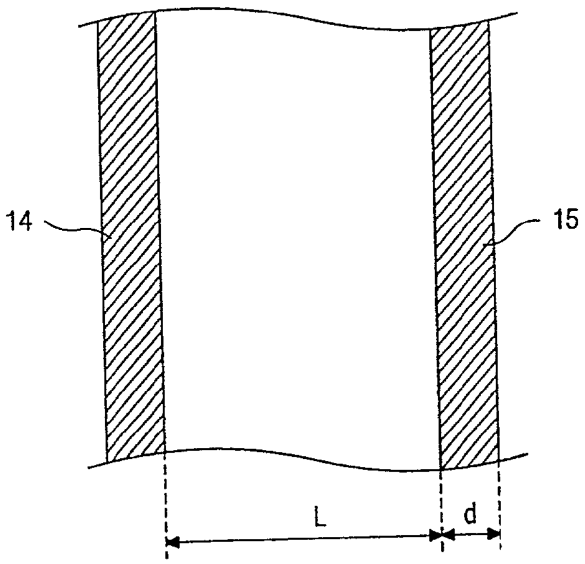
(related art)

FIG. 6A



(related art)

FIG. 6B



(related art)
FIG. 7

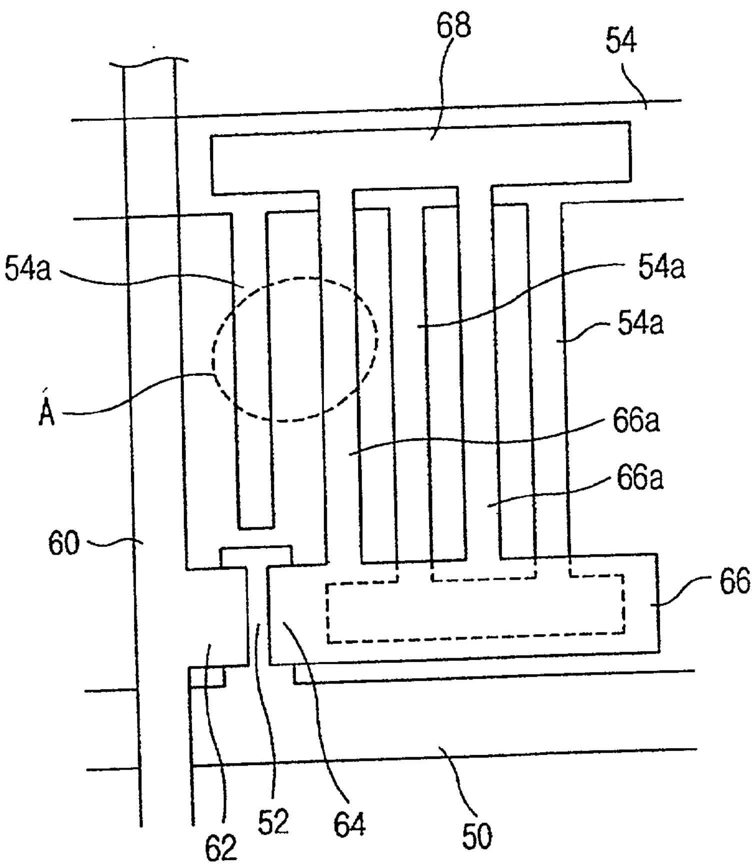


FIG. 8

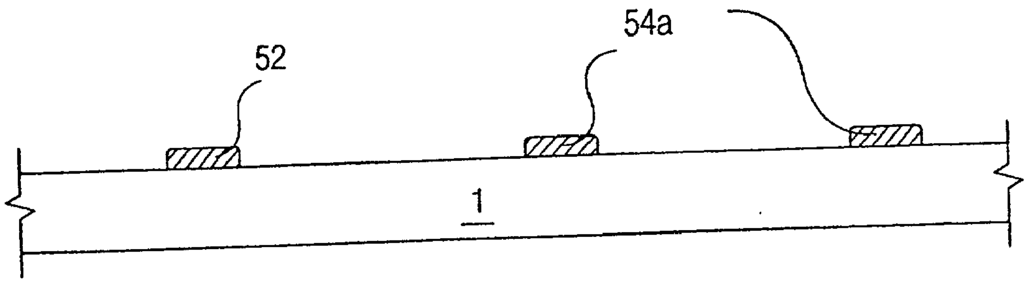


FIG. 9A

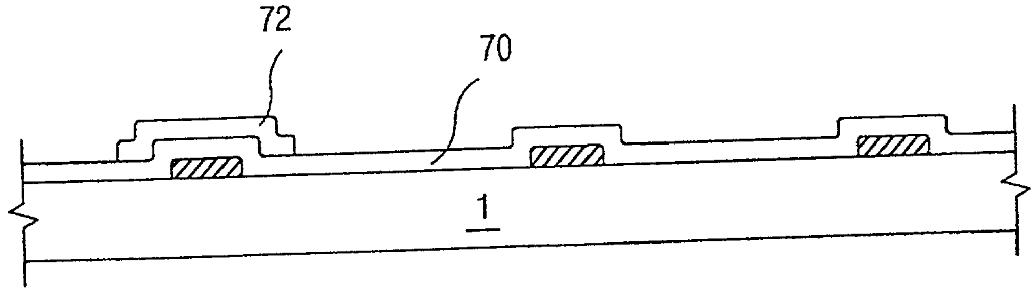


FIG. 9B

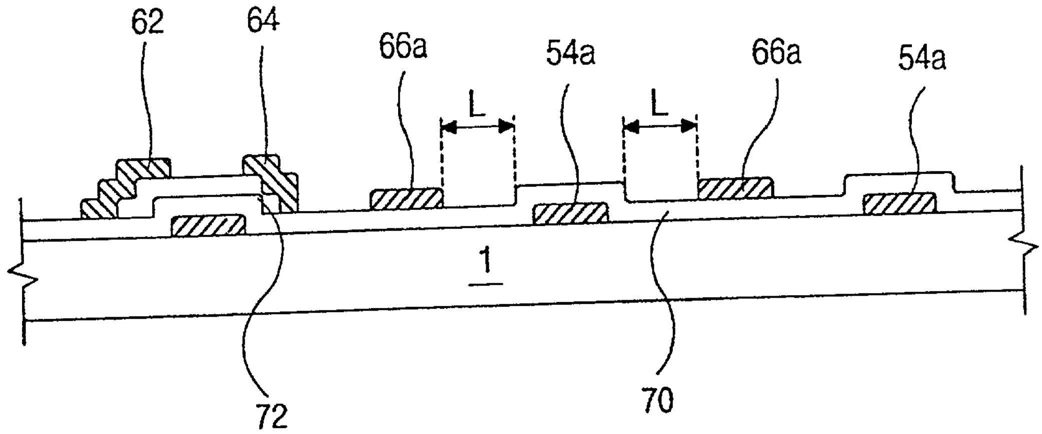


FIG. 9C

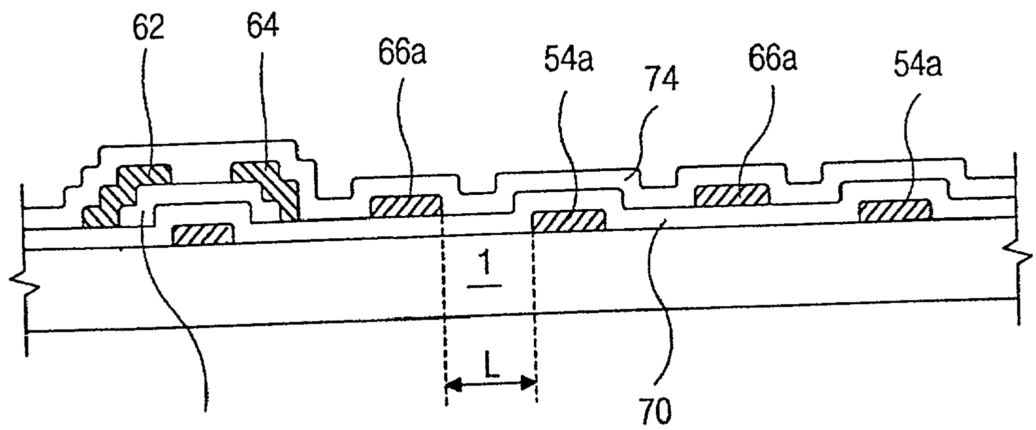


FIG. 9D

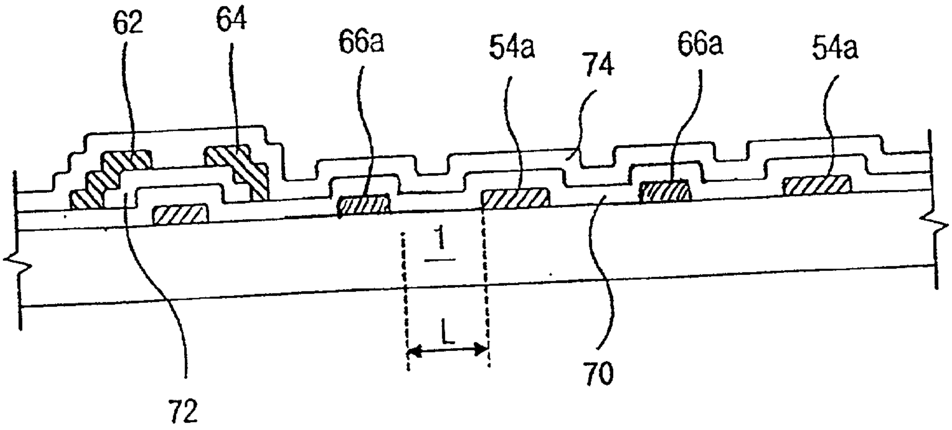


FIG. 9E

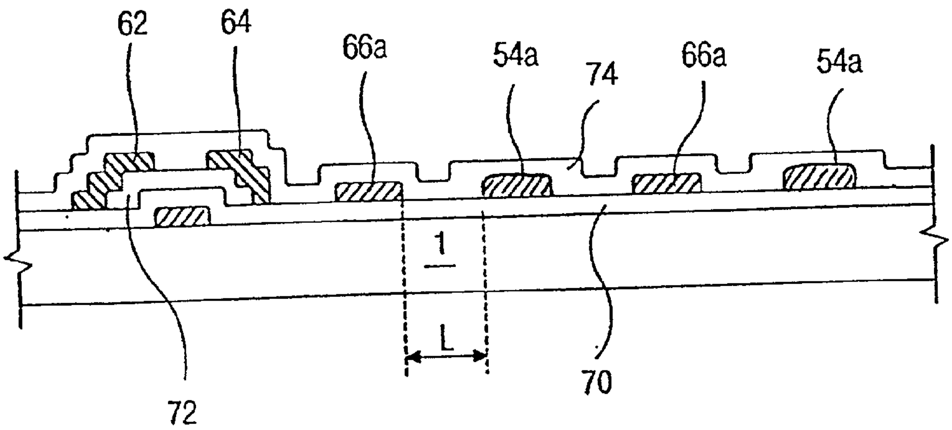


FIG. 9F

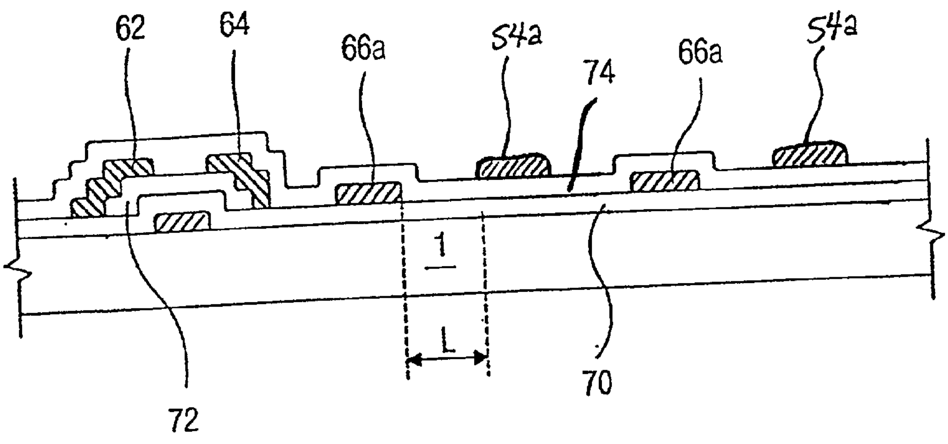


FIG. 9G

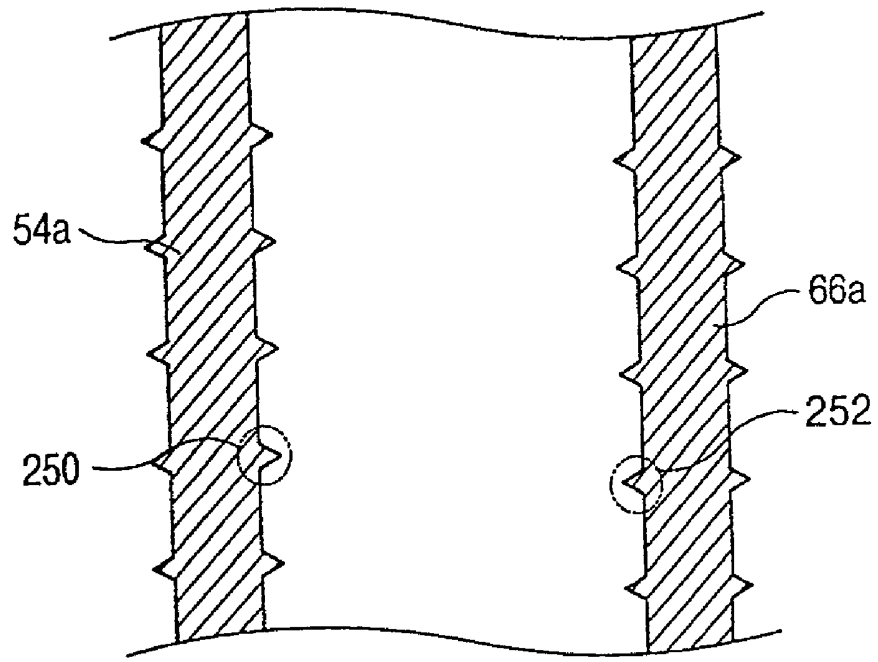


FIG. 10

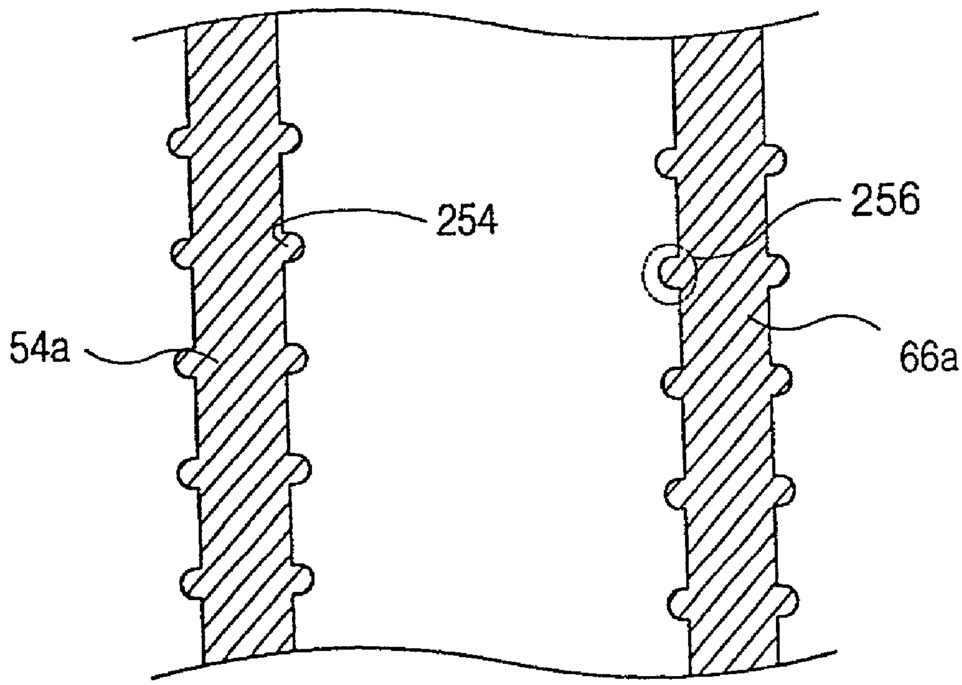


FIG. 11

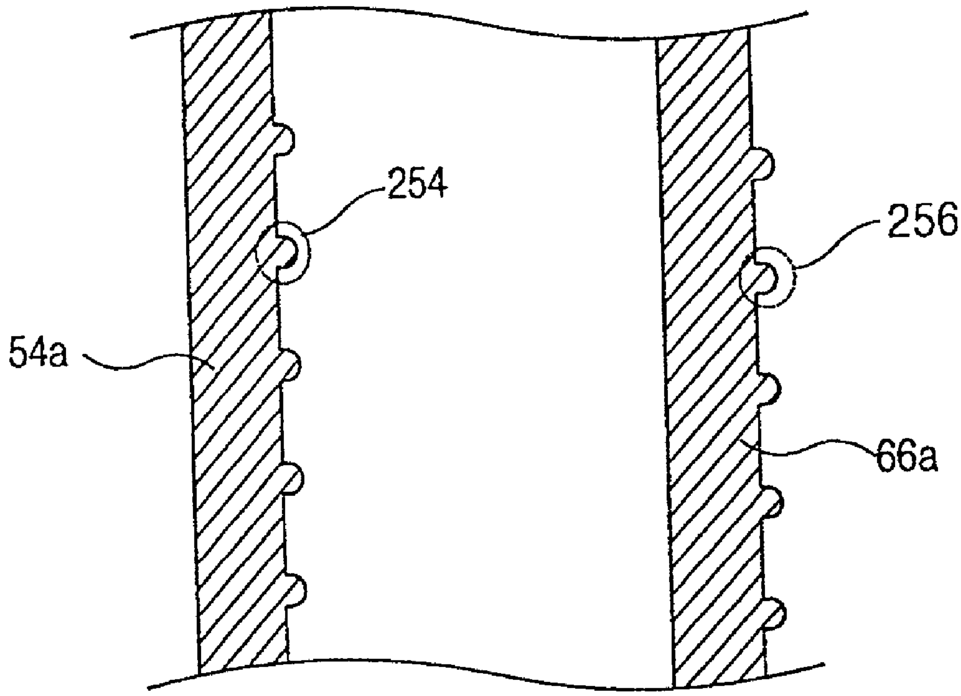


FIG. 12

IN-PLANE SWITCHING LCD PANEL

[0001] This application claims the benefit of Korean Patent Application No. 1999-56020, filed on Dec. 9, 1999, which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a liquid crystal display (LCD) device, and more particularly, to a liquid crystal display device implementing in-plane switching (IPS) where an electric field to be applied to liquid crystal is generated in a plane parallel to a substrate.

[0004] 2. Discussion of the Related Art

[0005] Recently, liquid crystal display (LCD) devices with light, thin, low power consumption characteristics have been used in office automation (OA) equipments and video units and the like. Typically there are two types of LCDs—a twist nematic (TN) mode and a super twist nematic (STN) mode. Although TN-LCDs and STN-LCDs have been in wide use, they have a drawback of a very narrow viewing angle. In order to solve the problem, IPS-LCD devices have been proposed. An IPS-LCD device includes a lower substrate where a pixel electrode and a common electrode are disposed, an upper substrate having no electrode and a liquid crystal is interposed between the upper and lower substrates.

[0006] As shown in **FIG. 1**, lower and upper substrates **1***a* and **1***b* are spaced apart from each other, and a liquid crystal "LC" is interposed therebetween. The lower and upper substrates are called array and color filter substrates, respectively. On the lower substrate **1***a,* pixel and common electrodes **15** and **14** are disposed. The pixel and common electrodes **15** and **14** are parallel with and spaced apart from each other. On a surface of the upper substrate **1***b,* a color filter **25** is disposed facing the lower substrate **1***a*. The pixel and common electrodes **15** and **14** apply an electric field "E" to the liquid crystal "LC". The liquid crystal "LC" has a negative dielectric anisotropy, and thus it is aligned parallel with the electric field "E".

[0007] FIGS. **2** to **5** conceptually illustrate operation modes of a typical IPS-LCD device. When the electric field is not generated between the pixel and the common electrodes **15** and **14**, the long axes of the LC molecules "LC" maintain an angle relative to a perpendicular line to the parallel pixel and common electrodes **15** and **14**. For example, the angle is 45 degrees.

[0008] When the electric field is generated between the pixel and common electrodes **15** and **14**, because both of the pixel and common electrodes **15** and **14** are formed on the lower substrate **1***a,* the in-plane electric field "E", which is parallel to the surface of the lower substrate **1***a*, is generated between the pixel and common electrodes **15** and **14**. Accordingly, the LC molecules "LC" move to coincide the long axes thereof with the electric field direction, and the LC molecules "LC" become aligned such that the long axes thereof is parallel with the perpendicular line to the pixel and common electrodes **15** and **14**.

[0009] By the above-mentioned operation modes and with additional elements such as polarizers and alignment layers, the IPS-LCD device displays images. The IPS-LCD device has wide viewing angles, low color dispersion qualities, and the fabricating processes thereof are simpler as compared to other LCD devices. But, since the pixel and common electrodes are disposed on the same plane of the lower substrate, the transmittance and aperture ratio are low.

[0010] For the sake of discussing the above-mentioned problem of the IPS-LCD device in detail, the structure of the IPS-LCD device will be described in detail with reference to **FIGS. 6A and 6B**.

[0011] **FIG. 6A** is a plan view illustrating in detail the structure of one pixel region in the IPS-LCD device, specifically, a unit pixel region **10**. In addition, a cross-sectional view taken along a line "B-B" in **FIG. 6A** is illustrated in **FIG. 6B**.

[0012] On the surface of the transparent substrate 1A adjacent to the liquid crystal layer, a gate line (or scan signal line) **2** made of, for example, aluminum (Al) is formed extending along the x-direction. In addition, a common line (or reference signal line) **4** is formed extending along the x-direction, close to the gate line **2** on the +y-direction side thereof. The common line **4** is also made of, for example, Al. A region surrounded by the gate line **2**, the common lines **4**, and the data lines **3** constitutes a pixel region, as previously described.

[0013] In addition, the pixel region **10** includes a common electrode **14** formed by the common line **4**, and another common electrode **14** formed adjacent to the gate line **2**. The pair of horizontally extending common electrodes **14** are positioned adjacent to one of a pair of data lines **3** (on the right side of **FIG. 6A**), and are electrically connected to each other through a conductive layer **14**A which is formed simultaneously with the common electrodes **14**.

[0014] In the structure described above, the pair of common electrodes **14** extend in the direction parallel with the gate line **2**. In other words, the common electrodes **14** take the form of a strip extending in a direction perpendicular to the data lines **3**.

[0015] On the surface of the lower substrate **1***a* on which the gate lines and other lines discussed above are formed, a first insulating film **11** (see **FIG. 6B**) made of, for example, silicon nitride is formed overlying the gate line **2**, the common lines **4**, and the common electrodes **14**. This first insulating film **11** functions as an inter-layer insulating film for insulating the gate line **2** and the common lines **4** from the data lines **3** as a gate-insulating layer for a region in which a thin film transistor "TFT" including a drain electrode **3***a* and a source electrode **15***a* is formed. The first insulating film **11** also acts as a dielectric film for a region in which a capacitor Cstg is formed. A semiconductor layer **12** for the TFT is formed near a cross point of the gate and data lines **2** and **3**. On the other surface of the lower substrate **1***a,* a first polarization layer **18** is formed.

[0016] On the first insulating film **11**, a pixel electrode **15** is formed parallel with the common electrode **14**. An end portion thereof is electrically connected with the conductive layer **14***a,* and the other portion thereof is electrically connected with the source electrode **15***a*. A first planar film **16** is formed on the first insulating film **11** to cover the pixel electrode **15**, and on the first planar film **16**, a first alignment film **17** is formed.

[0017] **FIG. 6B** illustrates a cross-sectional view of the upper substrate **1***b* on which a black matrix **300** is formed.

In the opening of the black matrix **300**, a color filter **25** is formed to fill the opening. Then, a second planar film **27** is formed to cover the color film **25** and the black matrix **300**, and a second alignment layer **28** is formed on the surface of the second planar film **27** facing the liquid crystal layer.

[**0018**] The color filter **25** is formed to define three sub-pixel regions adjacent to and extending along the data line **3** and including a red (R) filter, a green (G) filter, and a blue (B) filter, for example, from the top of the three sub-pixel regions. The three sub-pixel regions constitute one pixel region for a color display.

[**0019**] A second polarization layer **29** is arranged on the surface of the upper substrate **1***b* opposite to the surface adjacent to the liquid crystal layer on which various films are formed as described above.

[**0020**] In **FIG. 6B, a** voltage applied between the common electrodes **14** and the pixel electrode **15** causes an electric field E to be generated in the liquid crystal layer LC in parallel with the respective surfaces of the lower and upper substrates **1***a,* **1***b*. This is the reason why the illustrated structure is referred to as in-plane switching.

[**0021**] As shown in **FIG. 7**, if a distance "L" between the common and pixel electrodes **14** and **15** becomes longer, the aperture ratio problem can be solved. However, a larger "L" causes the threshold voltage to drive the liquid crystal to be higher. That is to say, the threshold voltage "V_{th}" is proportional to "L/d", where "d" is the width of the pixel electrode **15** (V_{th} L/d). If the distance "L" becomes longer, the electric field generated between the pixel and common electrodes becomes weaker. Accordingly, the voltage difference between the pixel and common electrodes needs to be larger for a normal operation of the IPS-LCD device.

[**0022**] However, driving circuits that provide the voltage difference to the electrodes have limitations making it difficult to increase the voltage difference. Accordingly, the distance "L" can not be increased to solve the aperture ratio problem.

SUMMARY OF THE INVENTION

[**0023**] Accordingly, the present invention is directed to an IPS-LCD device that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

[**0024**] An advantage of the present invention is to provide an IPS-LCD device having a high aperture ratio.

[**0025**] Another advantage of the present invention is to provide an IPS-LCD device having a low threshold voltage.

[**0026**] Additional features and advantages of the invention will be set forth in the description which follows and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[**0027**] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, the present invention provides a liquid crystal display device including a substrate; a thin film transistor on the substrate; a pixel electrode having a plurality of first tips, the first tips being formed at at least one edge of the pixel electrode; and a common electrode having a plurality of second tips, the second tips being formed at at least one edge of the pixel electrode, and the common electrode being substantially parallel with the pixel electrodes.

[**0028**] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWING

[**0029**] The accompanying drawings, which are included to provide a further understanding of the invention and 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.

[**0030**] In the drawings:

[**0031**] **FIG. 1** is a cross sectional view illustrating a conventional IPS-LCD panel;

[**0032**] FIGS. **2** to **5** are perspective views illustrating operation modes of the conventional IPS-LCD device;

[**0033**] **FIG. 6A** is a plan view of a pixel region illustrating an embodiment of a liquid crystal display device according to the present invention;

[**0034**] **FIG. 6B** is a cross-sectional view taken along a line "B-B" in **FIG. 6A**;

[**0035**] **FIG. 7** is an enlarged view illustrating a portion "A" of **FIG. 6A**;

[**0036**] **FIG. 8** is a plane view of an IPS-LCD device according to a preferred embodiment of the present invention;

[**0037**] **FIGS. 9A** - **9**D illustrate a sequence of fabricating processes for the liquid crystal display device of the present invention;

[**0038**] **FIGS. 9E** - **9**G illustrate alternative embodiments of the liquid crystal display device of the present invention;

[**0039**] **FIG. 10** is a enlarged plane view illustrating a portion "A" of **FIG. 8**; and

[**0040**] **FIGS. 11 and 12** are plane views illustrating modifications of the preferred embodiment of **FIG. 9**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[**0041**] Reference will now be made in detail to the preferred embodiment of the present invention, example of which is illustrated in the accompanying drawings.

[**0042**] As shown in **FIG. 8**, gate and common lines **50** and **54** are arranged transversely and parallel with each other. A data line **60** is arranged perpendicular to the gate and common lines **50** and **54**. Near a cross point of the gate and data lines **50** and **60**, gate electrode **52** and source electrode **62** are formed, preferably extending from the gate line **50** and the data line **60**, respectively. The source electrode **62** overlaps a portion of the gate electrode **52**.

[0043] A plurality of spaced apart common electrodes **54***a* are positioned perpendicular to the common line **54** and connected therewith. A first connecting line **66** is connected to the drain electrode **64**, and a plurality of pixel electrodes **66***a* are positioned perpendicular to the first connecting line **66**. First end portions of the pixel electrodes **66***a* are connected to the first connecting line **66**, and second end portions of the pixel electrodes **66***a* are connected to a second connecting line **68** that is positioned over the common line **54**. Accordingly, the common electrodes **54***a* and the pixel electrodes **66***a* are parallel with and spaced apart from each other in an alternating way.

[0044] **FIGS. 9A** to 9D illustrate a sequence of fabricating processes for the above-mentioned array substrate.

[0045] In **FIG. 9A**, on the array substrate **1**, a first metal layer is deposited and patterned to form the gate electrode **52** and the plurality of common electrodes **54***a*. The first metal layer is preferably selected from a group consisting of chromium (Cr), aluminum (Al), aluminum alloy (Al alloy), molybdenum (Mo), tantalum (Ta), tungsten (W), and antimony (Sb), and an alloy thereof.

[0046] In **FIG. 9B, a** gate-insulating layer **70** is formed on the array substrate **1** to cover the gate and common electrodes **52** and **54***a*. On the gate-insulating layer **70**, an active layer **72** is formed. The gate-insulating layer **70** preferably includes silicon nitride (SiNx) or silicon oxide (SiO_2), while the active layer **72** preferably includes an amorphous silicon (a-Si) layer and a doped amorphous silicon (n+ a-Si) layer.

[0047] In **FIG. 9C, a** second metal layer is deposited and patterned to form the source and drain electrodes **62** and **64** on the active layer **72**, and the pixel electrodes **66***a* on the gate-insulating layer **70**. The pixel electrodes **66***a* are spaced apart from the adjacent common electrode **54***a* by a distance "L".

[0048] In **FIG. 9D, a** passivation layer **74** is formed to cover the source, drain, and pixel electrodes **62**, **64**, and **66***a*. The passivation layer **74** protects the source, drain, and pixel electrodes **62**, **64**, and **66***a* from, for example, outer humidity or contaminants.

[0049] Although the figures illustrate the common and pixel electrodes as being formed in different or layers, they can be preferably formed in the same layer with the gate electrode **52** (see **FIG. 9E**) or alternatively, the drain and source electrodes **62** and **64** (see **FIG. 9F**). Further, the common electrode **54***a* can be formed on the passivation layer **74** with the pixel electrode **66***a* formed on the gate-insulating layer **70** (see **FIG. 9G**).

[0050] After forming the array substrate as shown in **FIG.** 9D, first and second orientation layers (not shown) are respectively formed on the array substrate **1** and a color filter substrate (not shown). The first and second orientation layers preferably include polyamic acid or polyimide. Thereafter, a liquid crystal layer is interposed between the first and second substrates.

[0051] **FIG. 10** shows common and pixel electrodes **54***a* and **66***a* disposed on the array substrate shown in **FIG. 8**, according to a preferred embodiment of the present invention. As shown in **FIG. 10**, the common and pixel electrodes **54***a* and **66***a* are parallel with and spaced apart from each other. Along the edges of the common and pixel electrodes **54***a* and **66***a*, a plurality of first and second tips **250** and **252** protrude, respectively, which are spaced apart from each other. The first and second tips have a triangular shape in **FIG. 10**. The common and pixel electrodes **54***a* and **66***a* are preferably selected from a group consisting of chromium (Cr), aluminum (Al), aluminum alloy (Al alloy), molybdenum (Mo), tantalum (Ta), tungsten (W), antimony (Sb), and indium tin oxide (ITO), and an alloy thereof. The common and pixel electrodes **54***a* and **66***a* may be made of the same material or different materials and the tips, which preferably extend from each electrode, have the same material as the electrode. The first and second tips **250** and **252** preferably have the same structure.

[0052] When a voltage difference is applied to the common and pixel electrodes **54***a* and **66***a*, an electric field is generated between them. Since the electric field around the tips becomes stronger than that of the other regions, the sum of the electric field becomes stronger as compared with the conventional IPS-LCD device under the same condition. Accordingly, the IPS-LCD device according to the preferred embodiment of the present invention requires a lower threshold voltage for operation. In other words, to improve the aperture ratio, the distance between the pixel and common electrodes can be enlarged while maintaining a low threshold voltage.

[0053] **FIGS. 11 and 12** show modifications according to the preferred embodiments of the present invention. The first and second tips **254** and **256** preferably have a shape of a semicircle as opposed to a triangle as shown in **FIG. 10**. Further, as shown in **FIG. 12**, the common and pixel electrodes **54***a* and **66***a* preferably include the first and second tips **254** and **256**, respectively, at only one edge of each of the electrodes. Although **FIG. 11** shows the first and second tips protruding from the right edges, they may also protrude from the left edges.

[0054] Although the first and second tips are shown as having either a semicircular shape or a triangular shape, other shapes are also contemplated in the present invention such as a square shape or a rectangular shape, for example.

[0055] As described above, the preferred embodiment of the present invention has advantages of a low threshold voltage and high aperture ratio as compared to the conventional device.

[0056] It will be apparent to those skilled in the art that various modifications and variation can be made in the method of manufacturing a thin film transistor of the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover 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 substrate;

a thin film transistor on the substrate;

a pixel electrode having a plurality of first tips, the first tips being formed at at least one edge of the pixel electrode; and a common electrode having a plurality of second tips, the second tips being formed at at least one edge of the pixel electrode, the common electrode being substantially parallel with the pixel electrodes.

2. The liquid crystal display device of claim 1, wherein at least one of the pixel and common electrodes includes a material selected from a group consisting of chromium (Cr), aluminum (Al), aluminum alloy (Al alloy), molybdenum (Mo), tantalum (Ta), tungsten (W), antimony (Sb), and indium tin oxide (ITO).

3. The liquid crystal display device of claim 1, further comprising an alignment layer on the pixel and common electrodes.

4. The liquid crystal display device of claim 3, wherein the alignment layer is selected from a group consisting of polyamic acid and polyimide.

5. The liquid crystal display device of claim 1, wherein the thin film transistor includes gate, source, and drain electrodes.

6. The liquid crystal display device device of claim 5, wherein the thin film transistor comprises:

a gate electrode on the substrate;

a gate insulating layer on the gate electrode;

a semiconductor layer on the gate insulating layer; and

source and drain electrodes on the semiconductor layer.

7. The liquid crystal display device of claim 5, wherein at least one of the pixel and common electrodes is on the same layer as the gate electrode.

8. The liquid crystal display device of claim 5, wherein at least one of the pixel and common electrodes is on the same layer as the source electrode.

9. The liquid crystal display device of claim 5, wherein the pixel electrode and the common electrode are on the same layer.

10. The liquid crystal display device of claim 9, wherein the pixel electrode is on the same layer as the gate electrode.

11. The liquid crystal display device of claim 9, wherein the pixel electrode is on the same layer as the source electrode.

12. The liquid crystal display device of claim 9, wherein at least one of the pixel and common electrodes is above source, drain and gate electrode layers.

13. A liquid crystal display device comprising:

a first substrate including a switching device;

a second substrate including a color filter;

a liquid crystal layer between the first and second substrates; and

first and second electrodes on the first substrate, at least one of the first and second electrodes having a plurality of tips.

14. The liquid crystal display device of claim 13, wherein at least one of the first and second electrodes includes a material selected from a group consisting of chromium (Cr), aluminum (Al), aluminum alloy (Al alloy), molybdenum (Mo), tantalum (Ta), tungsten (W), antimony (Sb), and indium tin oxide (ITO).

15. The liquid crystal display device of claim 13, further comprising a first alignment layer on the first substrate.

16. The liquid crystal display device of claim 15, wherein the first alignment layer is selected from a group consisting of polyamic acid and polyimide.

17. The liquid crystal display device of claim 13, further comprising a second alignment layer on the second substrate.

18. The liquid crystal display device of claim 17, wherein the second alignment layer is selected from a group consisting of polyamic acid and polyimide

19. The liquid crystal display device of claim 13, wherein the first electrode and the second electrode are on the same layer.

20. The liquid crystal display device of claim 13, wherein the first electrode and the second electrode are on different layers.

21. The liquid crystal display device of claim 13, wherein the switching device includes a thin film transistor.

22. The liquid crystal display device of claim 21, wherein the thin film transistor includes a gate, a source, and a drain electrode.

23. The liquid crystal display device of claim 22, wherein the first and second electrodes are on the same layer as the gate electrode.

24. The liquid crystal display device device of claim 21, wherein the thin film transistor comprises:

a gate electrode on the substrate;

a gate insulating layer on the gate electrode;

a semiconductor layer on the gate insulating layer; and

a source and drain electrodes on the semiconductor layer.

25. The liquid crystal display device of claim 22, wherein at least one of the first and second electrodes is on the same layer as the gate electrode.

26. The liquid crystal display device of claim 22, wherein at least one of the first and second electrodes is on the same layer as the source electrode.

27. The liquid crystal display device of claim 21, wherein the first electrode and the second electrode are on the same layer.

28. The liquid crystal display device of claim 27, wherein the first electrode is on the same layer as the gate electrode.

29. The liquid crystal display device of claim 27, wherein the first electrode is on the same layer as the source electrode.

30. The liquid crystal display device of claim 27, wherein at least one of the first and second electrodes is above source, drain and gate electrode layers.

* * * * *

专利名称(译)	面内切换LCD面板		
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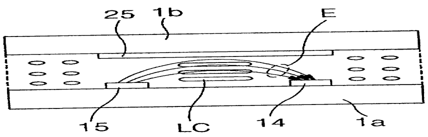
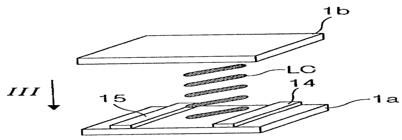
IPC分类号	G02F1/1343 G02F1/136 G02F1/1337		
CPC分类号	G02F1/134363		
优先权	1019990056020 1999-12-09 KR		
其他公开文献	US6583841		
外部链接	Espacenet USPTO		

摘要(译)

一种液晶显示面板的阵列基板，包括基板;基板上的薄膜晶体管;像素电极，具有多个第一尖端，第一尖端形成在像素电极的至少一个边缘上;以及具有多个第二尖端的公共电极，第二尖端形成在像素电极的至少一个边缘处，并且公共电极与像素电极平行。



(related art)
FIG. 1



(related art)
FIG. 2

(related art)
FIG. 3