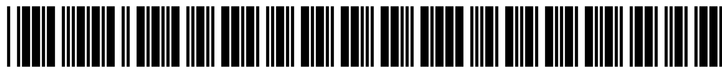

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(54) **LIQUID CRYSTAL DISPLAY DEVICE**

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(57) **ABSTRACT**

In a liquid crystal display device that uses a TFT, a contact hole is formed to connect an image signal line. An organic film is formed so as to cover the image signal line, and a common electrode, which is a transparent electrode, is formed on the organic film. An interlayer insulating film is formed on the common electrode. A through hole is formed in the interlayer insulating film, and the diameter of the through hole is greater than the diameter of the contact hole.

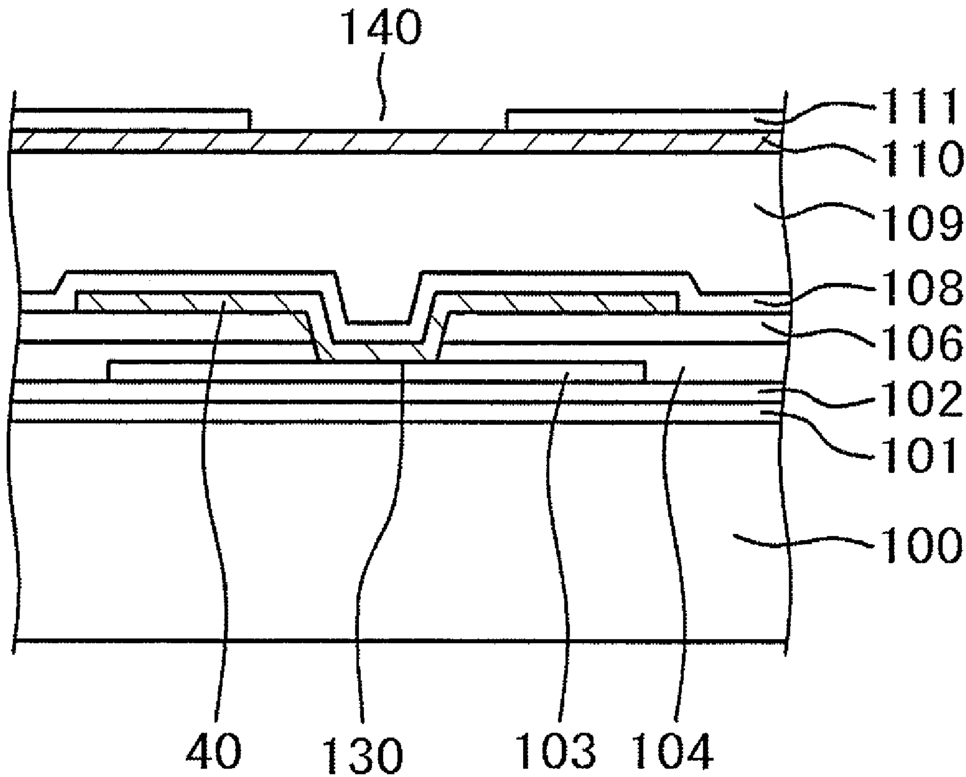


FIG. 1

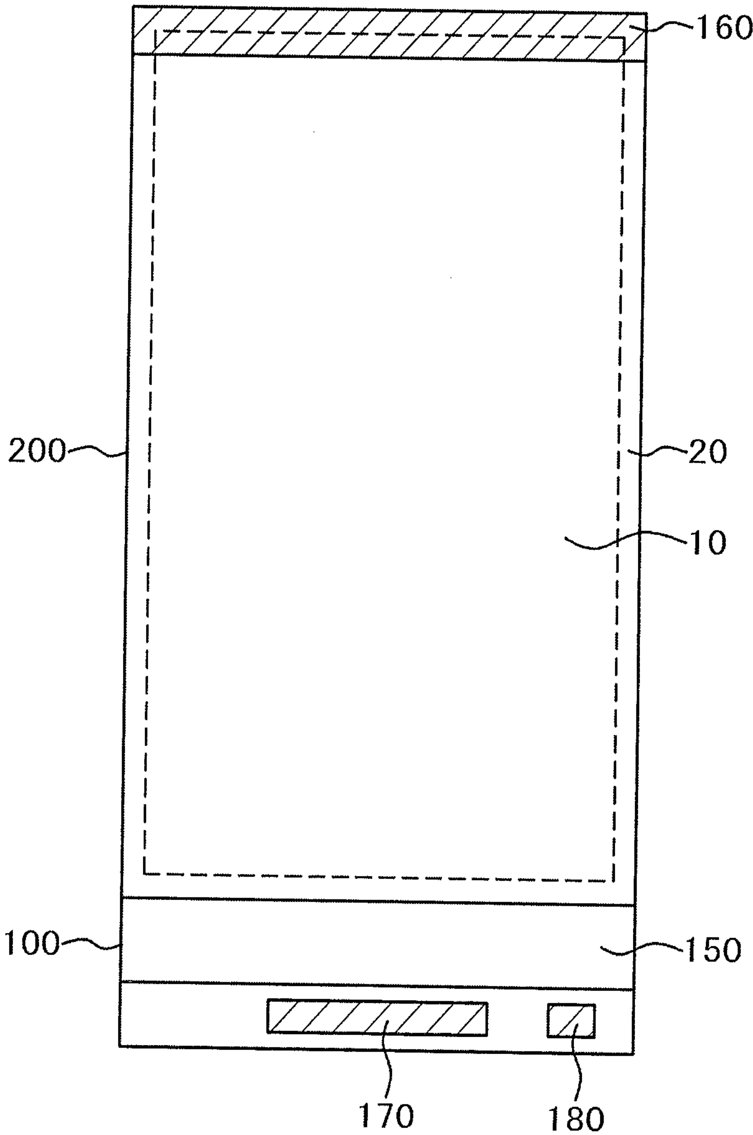


FIG. 2

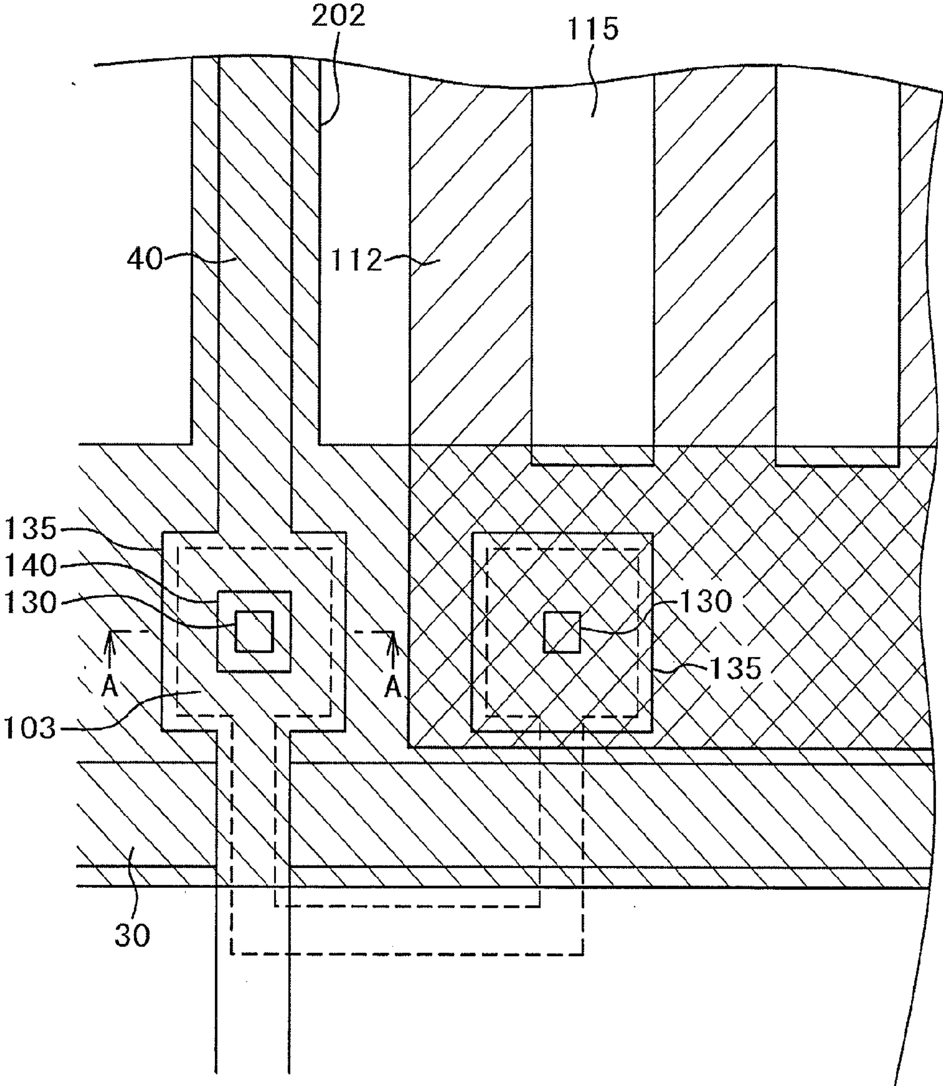


FIG. 3

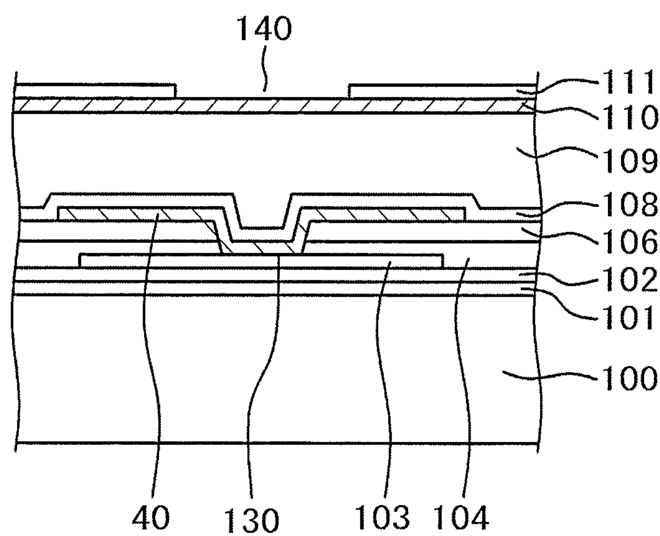
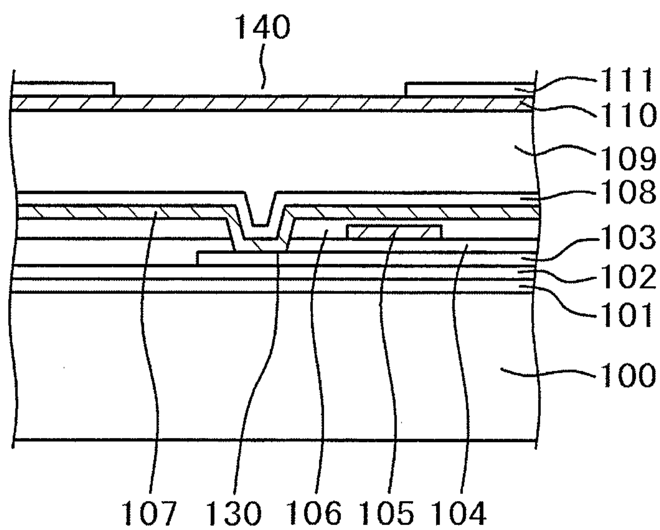


FIG. 4



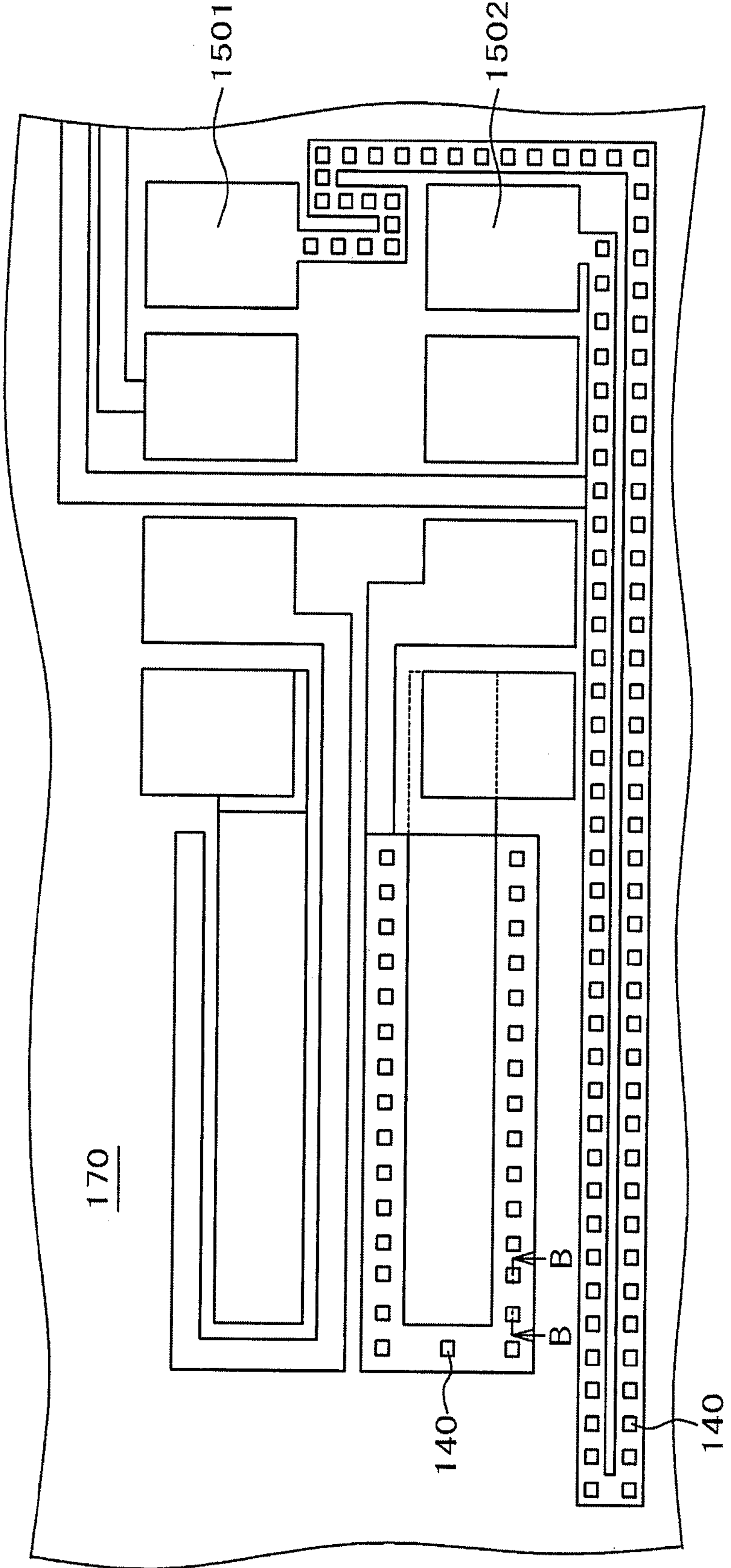


FIG. 5
1501
1502
170
B
B
140
140

FIG. 6

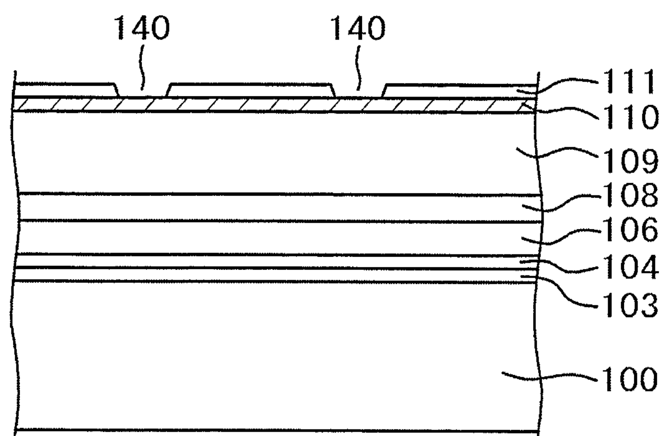


FIG. 7

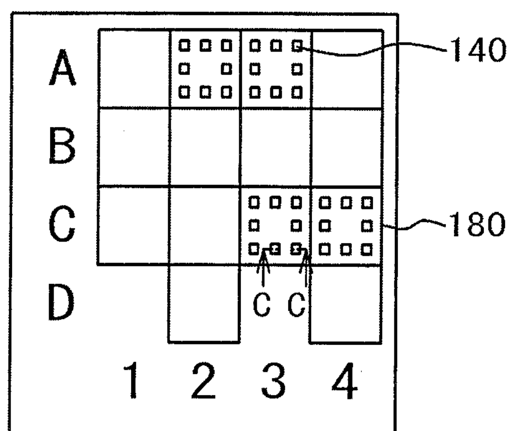
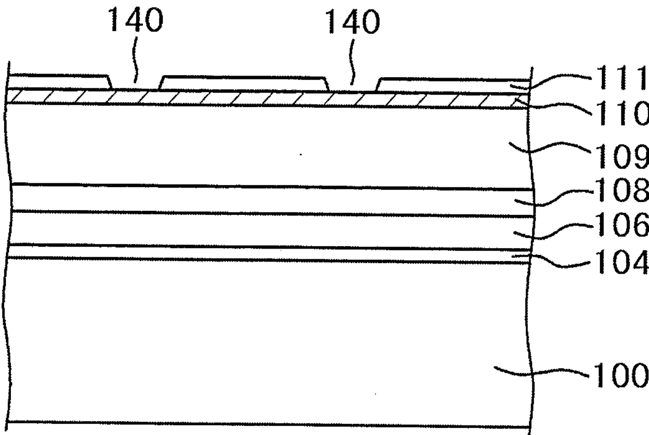


FIG. 8



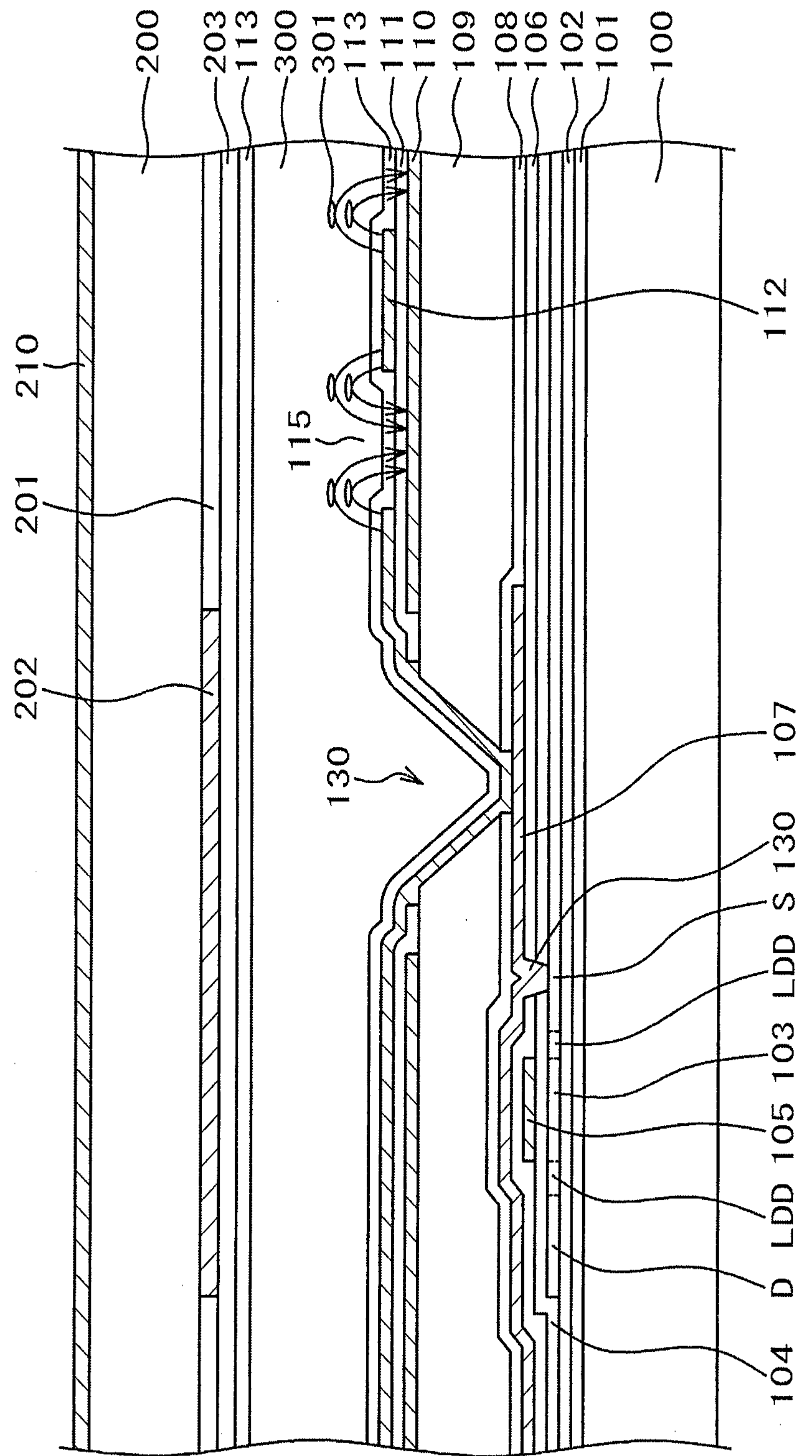


FIG. 9
200
203
113
300
301
113
111
110
109
108
106
102
101
100
210
201
202
115
112
130
107
S 130
LDD
103
105
LDD
D
104

LIQUID CRYSTAL DISPLAY DEVICE

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of U.S. application Ser. No. 13/311,595, filed Dec. 6, 2011, the contents of which are incorporated herein by reference.

CLAIM OF PRIORITY

[0002] The present application claims priority from Japanese Patent Application JP 2010-279155 filed on Dec. 15, 2010, the content of which is hereby incorporated by reference into this application.

FIELD OF THE INVENTION

[0003] The present invention relates to a display device, and more particularly, to a liquid crystal display device designed to prevent peeling of a film formed on an organic passivation film.

BACKGROUND OF THE INVENTION

[0004] A liquid crystal display device includes a TFT substrate in which pixels each having a pixel electrode, a thin film transistor (TFT), and the like are arranged in a matrix form. Further, a counter substrate is disposed opposite to the TFT substrate, in which color filters and the like are formed at positions corresponding to the pixel electrodes of the TFT substrate. A liquid crystal is interposed between the TFT substrate and the counter substrate. Then, the light transmittance is controlled by liquid crystal molecules in each pixel to form an image.

[0005] The use of liquid crystal display devices is growing in various fields due to its flatness and lightweight. Small-sized liquid crystal display devices are widely used in mobile phones and digital still cameras (DSCs). In the liquid crystal display device, the viewing angle characteristics are a problem. The viewing angle is a phenomenon in which the brightness changes or the color changes between when the display is viewed from the front and when the display is viewed from an oblique direction. The viewing angle characteristics are excellent in the in-plane switching (IPS) mode for driving liquid crystal molecules by the electric field in the horizontal direction.

[0006] There are many different types of IPS mode. For example, a common electrode is formed in a planar shape, on which a pixel electrode having a slit is provided with an insulating film interposed therebetween, to rotate liquid crystal molecules by the electric field generated between the pixel electrode and the common electrode. This type can increase the light transmittance, and is now a mainstream IPS mode. An organic passivation film is used for flattening the base on which the common electrode is formed. However, the organic passivation film is highly hygroscopic and absorbs water from the air when it is left outside. Then, in the film formation, the water absorbed by the organic passivation film is released during heat treatment. This affects the film formed on the organic passivation film, causing it to peel off.

[0007] As a method to solve such a problem, JP-A No. 271103/2009 describes a configuration in which an interlayer insulating film is formed on an organic passivation film on an image signal line, and a through hole is formed along the image signal line in the interlayer insulating film to allow gas present in the organic passivation film to be released from the through hole. Further, in JP-A No. 271103/2009, the through hole is covered by a transparent electrode that is electrically connected to the common electrode.

[0008] In order to describe the problem in the related art, first the cross-sectional structure of an IPS liquid crystal display device will be described. FIG. **9** is a cross-sectional view showing the structure of a pixel portion of a display area **10** of the liquid crystal display device. Note that the cross-sectional view of FIG. **9** is an example of the basic structure, and does not correspond one-to-one to the figures such as FIG. **2** which is a top view of an embodiment of the present invention described below. As shown in FIG. **9**, the liquid crystal display device to which the present invention is applied is a top-gate TFT using poly-Si for a semiconductor layer **103**. In FIG. **9**, a first base film **101** of SiN and a second base film **102** of SiO_2 are formed on a glass substrate **100** by chemical vapor deposition (CVD). The role of the first base film **101** and the second base film **102** is to prevent the semiconductor layer **103** from being contaminated with impurities from the glass substrate **100**.

[0009] The semiconductor layer **103** is formed on the second base film **102**. In order to form the semiconductor layer **103**, a-Si film is formed on the second base film **102** by CVD, which is then converted into poly-Si film by laser annealing. Then, the poly-Si film is patterned by photolithography.

[0010] A gate insulating film **104** is formed on the semiconductor film. The gate insulating film **104** is SiO_2 film derived from tetraethyl orthosilicate (TEOS). This film is also formed by CVD. Then, a gate electrode **105** is formed on the gate insulating film **104**. The gate electrode **105** is formed on the same layer as a scan signal **30** at the same time. For example, the gate electrode **105** is formed from MoW film. When it is necessary to reduce the resistance of the scan line **30**, Al alloy is used.

[0011] The gate electrode **105** is patterned by photolithography. At the time of patterning, impurities such as phosphor or boron are doped in the poly-Si layer to form a source S or drain D in the poly-Si layer. Further, a lightly doped drain (LDD) layer is formed between a channel layer of the poly-Si layer, and the source S or drain D by using the photoresist in patterning the gate electrode **105**.

[0012] Then, a first interlayer insulating film **106** is formed of SiO_2 so as to cover the gate electrode **105**. The role of the first interlayer insulating film **106** is to provide electrical insulation between the gate line **105** and a source electrode **107**. The source electrode **107** is formed on the first interlayer insulating film **106**. The source electrode **107** is connected to the pixel electrode **112** through a contact hole **130**. In FIG. **9**, the source electrode **107** is made wide enough to cover the TFT. The drain D of the TFT is connected to the image signal line at a point not shown.

[0013] The source electrode **107** is formed on the same layer as the image signal line at the same time. In order to reduce the resistance, AlSi alloy is used for the source electrode **107** or the image signal line. In the AlSi alloy, hillock formation occurs or Al diffuses into other layers. In order to prevent such a phenomenon, AlSi is sandwiched by a barrier layer of MoW and a cap layer. Alternatively, Mow or MoCr may be used instead of using Al.

[0014] The source electrode **107** and the source S of the TFT are connected to each other through the contact hole **130** formed in the gate insulating film **104** and the first interlayer insulating film **106**. An inorganic passivation film **108** is formed and covers the source electrode **107** so as to protect

the entire TFT. Similarly to the first base film **101**, the inorganic passivation film **108** is formed by CVD.

[0015] An organic passivation film **109** is formed so as to cover the inorganic passivation film **108**. The organic passivation film **109** is formed of a photosensitive acrylic resin. Examples of the material of the organic passivation film, in addition to the acrylic resin, are a silicone resin, epoxy resin, and polyimide resin. The organic passivation film **109**, which has a role of a flattening film, is made thick. The thickness of the organic passivation film **109** is 1 to 4 μm, and in most cases, about 2 μm.

[0016] The contact hole **130** is formed in the inorganic passivation film **108** and in the organic passivation film **109** to provide electrical continuity between a pixel electrode **110** and the source electrode **107**. The photosensitive resin used as the organic passivation film **109** is applied and then exposed. In this way, only the portion exposed by light is dissolved with a specific developer. In other words, when the photosensitive resin is used, the formation of photoresist can be omitted. After the contact hole is formed in the organic passivation film **109**, the organic passivation film **109** is annealed at about 230° C. Thus, the organic passivation film **109** is completed. The organic passivation film **109** is dry etched using the resist as a mask, in order to form the contact hole in the inorganic passivation film **108**. In this way, the contact hole **130** is formed to provide electrical continuity between the source electrode **107** and the pixel electrode **110**.

[0017] The top surface of the organic passivation film **109** formed as described above is flat. Amorphous indium-tin-oxide (ITO) is deposited by sputtering on the top of the organic passivation film **109**, and then patterned using photoresist. Then, the ITO is etched by sulfuric acid to pattern the common electrode **110**. The common electrode **110** is formed in a planner shape, avoiding the contact hole **130**. Then, the ITO is polycrystallized by annealing at 230° C. in order to reduce the electrical resistance. The common electrode **110** is formed of ITO which is a transparent electrode. The thickness of the common electrode **110** is, for example, 77 μm

[0018] Then, a second interlayer insulating film **111** is formed by CVD so as to cover the common electrode **110**. At this time, the temperature condition of CVD is about 230° C., which is called low temperature CVD. Then, the second interlayer insulating film **111** is patterned by photolithography process. In FIG. **9**, the second interlayer insulating film **111** does not cover the side wall of the contact hole **130**. However, it is also possible that the second interlayer insulating film **111** covers the side wall of the contact hole **130**.

[0019] The other films, such as the first base film **101** and the inorganic passivation film **108** are formed by CVD at a temperature of 300° C. or more. In general, the higher the temperature at which a CVD film and the like is formed the greater the adhesion to the base film. However, the organic passivation film **109** has been formed below the second interlayer insulating film **111**. Thus, the characteristics of the organic passivation film **109** may be changed when the temperature is 230° C. or higher. For this reason, the second interlayer insulting film **111** is formed by low temperature CVD. When the second interlayer insulating film **111** is formed by low temperature CVD, there is a problem with the adhesion of the organic passivation film **109** to the other film, in particular to the common electrode **110** or the second interlayer insulating film **111**.

[0020] The pixel electrode **112** having a slit **115** is formed by sputtering the amorphous ITO on the second interlayer insulating film **111** through a photolithography process. The pixel electrode **112** is connected to the source electrode **107** through the contact hole **113**. When a signal voltage is applied to the pixel electrode **112**, electric field lines are generated between the common electrode **110** and the pixel electrode **112** through the slit **115**. The electric field rotates the liquid crystal molecules **301**, thereby controlling the transmittance of light from a backlight for each pixel to form an image. The pixel electrode **112** is formed of ITO which is a transparent conductive film. The thickness of the pixel electrode **112** is, for example, in the range of 40 nm to 70 nm. An oriented film **113** is formed so as to cover the pixel electrode **112**.

[0021] A counter substrate **200** is provided with a liquid crystal layer **300** interposed between the TFT substrate **100** and the counter substrate **200**. A color filter **201** is formed within the counter substrate **200**. The color filter **201** includes color filters of red, green, and blue in each pixel to form a color image. A black matrix **202** is formed between the color filters **201** to increase the contrast of the image. Note that the black matrix **202** also has a role as a light shielding film of the TFT to prevent the photocurrent from flowing into the TFT.

[0022] An overcoat film **203** is formed so as to cover the color filters **201** and the black matrix **202**. The surface of the color filters **201** and the black matrix **202** is rough. Thus, the surface is flattened by the overcoat film **203**. The oriented film **113** is formed on the overcoat film **203** for the initial orientation of the liquid crystal molecules. Note that FIG. **2** shows the case of the IPS, so that a counter electrode is formed on the side of the TFT substrate **100** but not on the side of the counter substrate.

[0023] As shown in FIG. **9**, in the case of the IPS, the conductive film is not formed inside the counter substrate **200**. As a result, the potential of the counter substrate **200** becomes unstable. In addition, external electromagnetic noise enters the liquid crystal layer **300** and affects the image. These problems eliminate by forming an external conductive film **210** on the outside of the counter substrate **200**. The external conductive film **210** is formed by sputtering the ITO which is the transparent conductive film.

[0024] As described above, the second interlayer insulating film formed on the organic passivation film is deposited by low temperature CVD at about 230° C. Thus, the adhesion of the second interlayer insulating film to the base film is low. The organic passivation film, which is formed below the second interlayer insulating film, absorbs water from the air when it is left outside. Then, when the organic passivation film is annealed to form various films on the organic passivation film, the water absorbed by the organic passivation film is released. At this time, the second interlayer insulating film peels off due to its low adhesion.

[0025] In order to solve the above problem, JP-A No. 271103/2009 describes a configuration in which a thin through hole is formed in the second interlayer insulating film and along the image signal line, so that the water absorbed by the organic passivation film is let out from the through hole. Further, in JP-A No. 271103/2009, the through hole is covered by the ITO film. The ITO film is electrically connected to the common electrode so as to have the shielding effect.

[0026] However, JP-A No. 271103/2009 has the following problem. That is, the second interlayer insulating film is formed by low temperature CVD, so that the film structure is less precise than the film structure formed by high temperature CVD. Thus, when the contact hole is formed along the image signal by etching, the width of the though hole is not

stabilized because of the unstable etching rate. As a result, the through hole is very likely to reach the pixel electrode. When the through hole reaches the pixel electrode, the disturbance of the electric field occurs in this portion of the pixel electrode, in which the liquid crystal molecules may not be controlled adequately. As a result, light leakage or other failure occurs. In addition, when the through hole is covered by the ITO film electrically connected to the common electrode, the pixel electrode and the common electrode are electrically connected to each other. As a result, the pixel is faulty.

[0027] Another problem of JP-A No. 271103/2009 is that when the through hole is formed in the second interlayer insulating film, its effect is reduced by covering the through hole formed along the image signal line by the ITO. In other words, also when the pixel electrode of ITO is formed on the second interlayer insulating film, the ITO film is annealed at 230° C. to reduce the resistance of the ITO. At the same time, the oriented film is also annealed to be imidized. Thus, the water absorbed by the organic passivation film is released when the ITO and oriented films are formed. For this reason, it is necessary to effectively release the water from the through hole formed in the second interlayer insulating film.

SUMMARY OF THE INVENTION

[0028] The present invention is to solve the above problems, and to prevent the second insulating film from peeling off, without reducing the process latitude and without degrading the image quality.

[0029] The present invention overcomes the above problems. Concrete steps are as follows. There is provided an IPS liquid crystal display device that uses a top gate TFT as a switching element. The TFT uses poly-Si as a semiconductor layer. An inorganic passivation film and an organic passivation film are formed so as to cover the TFT. A common electrode is formed on the organic passivation film. An interlayer insulating film is formed on the common electrode. Then, a pixel electrode having a slit is formed on the interlayer insulating film.

[0030] The width of an image signal line is wide in the vicinity of the TFT, in which the image signal line is electrically connected to the drain or source portion of the TFT through a contact hole. In the wide portion of the image signal line, a through hole is formed in the interlayer insulating film formed on the common electrode. In this way, gas generated in the organic passivation films is released from the through hole. Because the through hole for gas release is formed in the wide portion of the image signal line, if the diameter of the through hole varies by etching, this will not affect the driving of the liquid crystal molecules. Further, the diameter of the through hole for gas release is greater than the diameter of the contact hole for providing the electrical connection between the image signal line and the source or drain portion. In addition, the through hole for gas release is not covered by the conductive film such as ITO. Thus, it is possible to effectively release the gas from the organic passivation film to the outside.

[0031] The above configuration can also be applied to the IPS of the type in which the pixel electrode is formed on the organic passivation film, on which the interlayer insulating film is formed, and then the common electrode having a slit is formed on the interlayer insulating film.

[0032] Further, it is possible that the through hole for gas release is formed in the interlayer insulating film covering the peripheral circuit formed in the vicinity of the display area. Or it is also possible to form the through hole for gas release in the interlayer insulating film covering the portion in which a testing element group (TEG) pattern or an alignment mark is formed in the vicinity of the terminal portion of the TFT substrate.

[0033] According to the present invention, it is possible to prevent the interlayer insulating film from peeling off. As a result, the production yield of the liquid crystal display device can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] FIG. **1** is a top view of a liquid crystal display device;

[0035] FIG. **2** is a top view of a pixel portion according to a first embodiment of the present invention;

[0036] FIG. **3** is a cross-sectional view taken along line A-A in FIG. **2**;

[0037] FIG. **4** is a cross-sectional view according to a second embodiment of the present invention;

[0038] FIG. **5** is a top view showing an example in which the present invention is applied to the TEG pattern portion;

[0039] FIG. **6** is a cross-sectional view taken along line B-B in FIG. **5**;

[0040] FIG. **7** is a top view showing an example in which the present invention is applied to the alignment mark portion;

[0041] FIG. **8** is a cross-sectional view taken along line C-C in FIG. **7**; and

[0042] FIG. **9** is a cross-sectional view of the display area of the liquid crystal display device having a top-gate type TFT.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0043] Hereinafter, the present invention will be described in detail with reference to embodiments.

First Embodiment

[0044] FIG. **1** is a top view of a small liquid crystal display device used for portable electronic devices such as mobile phones, which is an example of the product to which the present invention is applied. In FIG. **1**, a counter substrate **200** is provided on a TFT substrate **100**. Although not shown, there is a liquid crystal layer interposed between the TFT substrate **100** and the counter substrate **200**. The TFT substrate **100** and the counter substrate **200** are bonded together by a sealing material **20** formed around the frame. In FIG. **1**, liquid crystal is injected between the substrates by a dropping method, so that no injection hole is formed.

[0045] The TFT substrate **100** is formed larger than the counter substrate **200**. In a portion of the TFT substrate **100** extending beyond the counter substrate **200**, a terminal portion **150** is formed to supply power, image signals, scan signals, and the like, to a liquid crystal cell **1**. Further, on the outside of the terminal portion **150**, there is formed a testing element group (TEG) used in the test of the circuit characteristics, or an alignment mark used in the alignment of the upper and lower boards in the production process.

[0046] FIG. **2** is a top view of the structure of a part of the pixel portion in the display area **10** shown in FIG. **1**. In FIG. **2**, the pixel electrode **112** having the slit **115** is formed in an area surrounded by an image signal line **40** and a scan line **30**. A common electrode, not shown, is formed below the pixel electrode **112** through a second interlayer insulating film not

shown. An image signal is supplied to the pixel electrode **112** from the image signal line **40** through TFT.

[0047] In FIG. **2**, a first TFT and a second TFT are arranged in series from the image signal line **40** to the pixel electrode **112**. In FIG. **2**, a contact hole **130** is formed in a wide portion of the image signal line **40** to connect the semiconductor layer **103** with the image signal line **40**. The semiconductor layer **103** extends beyond the scan line **30**, and is folded across the scan line **30** once again to connect to the pixel electrode **112**.

[0048] The semiconductor layer **103** includes a channel portion below the scan line **30** having a role as a gate electrode, in which a drain portion or a source portion is formed on either of the two sides of the scan line **30**. In FIG. **2**, for convenience, the side near the image signal line **40** is called the drain portion and the side near the pixel electrode **112** is called the source portion in each TFT. In other words, in the first TFT, the side connected to the image signal line **40** is the drain portion, and the side connected to the second TFT is the source portion, while in the second TFT, the side connected to the first TFT is the drain portion, and the side connected to the pixel electrode **112** is the source portion.

[0049] In FIG. **2**, the scan line **30** also functions as the gate electrode. The channel portion of the semiconductor layer **103** is formed below the scan line **30**. Thus, in FIG. **2**, two TFTs are present between the image signal line **40** and the pixel electrode **112**. In FIG. **2**, a through hole **140** is also formed in the contact portion of the image signal line **40** and the semiconductor layer **103**. The area of the through hole is greater than the area of the contact hole **130**. The through hole **140** is used to release gas from an organic passivation film **109** not shown in FIG. **2**.

[0050] In the counter substrate **200**, there is formed a black matrix in the area shown in FIG. **2**. The black matrix covers the image signal line **40**, the scan line **30**, the through hole **140**, the contact hole **130**, the channel portion of the TFT, and the like, formed on the TFT substrate **100** as described above.

[0051] FIG. **3** is a cross-sectional view taken along line A-A in FIG. **2**. The semiconductor layer **103** is formed on the first base film and on the second base film. A gate insulating film **104** and a first interlayer insulating film **106** are formed so as to cover the semiconductor layer **103**, on which the image signal line **40** is formed. The image signal line **40** is connected to the semiconductor layer **103** through the contact hole **130** that is formed in the gate insulating film **104** and in the first interlayer insulating film **106**. The inorganic passivation film **108** is formed so as to cover the image signal line **40** or the first interlayer insulating film **106**. Then, the organic passivation film **109** is formed on the inorganic passivation film **108**.

[0052] A common electrode **110** is formed on the organic passivation film **109**. Then, a second interlayer insulating film **111** is formed on the common electrode **110**. The second interlayer insulating film **111** provides electrical insulation between the common electrode **110** and the pixel electrode **112**. However, the pixel electrode **112** is not present on the image signal line **40**. In the present invention, the through hole **140** is formed in this area of the second interlayer insulating film **111** to be able to easily release water and the like absorbed by the organic passivation film **109**. Note that the oriented film is omitted in FIG. **3**.

[0053] As shown in FIGS. **2** and **3**, the diameter of the through hole **140** is grater than the diameter of the contact hole **130**. This is in order to effectively release the gas absorbed by the organic passivation film **109**. The portion in which the contact hole **130** is formed has a concave shape, so that peeling of the second interlayer insulating film **111** is more likely to occur. For this reason, it is effective to form the through hole **140** for gas release in this area.

[0054] As shown in FIG. **2**, the portion in which the through hole **140** for gas release is formed is the wide portion of the image signal line **40**, which also functions as a light shielding electrode **135**. Thus, if a disturbance in the orientation of the liquid crystal molecules occurs due to the influence of the through hole **140** for gas release, light leakage will not occur in this portion.

[0055] The through hole **140** for gas release is formed by etching. The second interlayer insulating film **111** is formed by low temperature CVD, so that the dimension control in etching is more difficult than the case of the film formed by high temperature CVD. However, as shown in FIG. **2**, the light shielding electrode **135** having a large area is formed below the through hole **140** for gas release. Thus, light leakage will not occur if the dimension of the through hole **140** for gas release varies.

[0056] Further, in FIG. **2**, the through hole **140** for gas release is formed very close to the scan line **30**. In the counter substrate **200**, the black matrix **202** is formed in the portion corresponding to the scan line **30**. Thus, even if light leakage occurs due to the influence of the through hole **140** for gas release, the light can also be blocked by the black matrix **202**.

[0057] As described above, according to the present invention, the through hole **140** for gas release is formed in the vicinity of the scan line **30** and in the wide portion of the image signal line **40**. Thus, it is possible to prevent peeling of the second interlayer insulating film **111**. Further, the wide portion of the image signal line **40** also functions as the light shielding electrode **135**, preventing side effects such as light leakage due to the formation of the through hole **140** for gas release.

[0058] Note that in the present invention, the through hole **140** for gas release formed in the second interlayer insulating film **111** is not covered by ITO. As a result, it is possible to release gas from the organic passivation film to the outside more effectively.

Second Embodiment

[0059] In an upper wiring circuit **160** corresponding to the shaded part above the display area **10** shown in FIG. **1**, a portion of protective wiring circuits or drive circuits is formed. These protective circuits have a TFT. The inorganic passivation film **108** and the organic passivation film **109** are formed so as to cover the TFT, on which the common electrode **110** is formed. Then, the second interlayer insulating film **111** is formed so as to cover the common electrode **110**. There is also a problem with the adhesion of the second interlayer insulating film **111**, similar to the case of the display area **10** described in the first embodiment.

[0060] FIG. **4** is a cross-sectional view in the area in which the protective circuit and the like are formed. FIG. **4** is a view of the cross section including TFT. FIG. **4** is the same as that described with reference to FIG. **9**, and so the details will be omitted here. In FIG. **4**, the source electrode **107** or drain electrode is connected through the contact hole **130** formed in the gate insulating film **104** and in the first interlayer insulating film **106**, both of which cover the semiconductor layer **103**. The source electrode **107** or drain electrode is the line formed in the same layer as the image signal line **40**. The inorganic passivation film **108** is formed so as to cover the

source electrode **107** or drain electrode. Then, the organic passivation film **109** is formed on the inorganic passivation film **108**.

[0061] On the inorganic passivation film **108**, there is an electrode of ITO formed at the same time as the common electrode **110**. This electrode is electrically connected to the common electrode **110**, and will also be referred to as the common electrode **110**. This common electrode **110** does not drive the liquid crystal molecules as in the case of FIG. **9**, which serves as a simple connection line or a shield electrode. The second interlayer insulating film **111** is formed so as to cover the common electrode **110**. The contact hole **130** is formed in the vicinity of the TFT, in which the adhesion of the second interlayer insulating film **111** is particularly low. Thus, the through hole **140** is formed in the corresponding portion of the second interlayer insulating film **111** to release gas from the organic passivation film **109**.

[0062] In FIG. **4**, the through hole **140** for gas release is formed on the outside of the display area **10**, so that light leakage or other problems will not occur if the dimension of the through hole **140** for gas release somewhat varies. Thus, a relatively larger through hole can be made on the outside of the display area **10** than inside. As a result, it is possible to prevent peeling of the second interlayer insulating film **111** more surely. Note that also in this embodiment, the through hole **140** for gas release formed in the second interlayer insulating film **111** is not covered by ITO. Thus, it is possible to release gas from the organic passivation film to the outside more effectively.

Third Embodiment

[0063] In the liquid crystal display device to which the present invention is applied, the TFT is formed of poly-Si, in which a drive circuit can be mounted within the liquid crystal display panel. When the drive circuit is formed within the liquid crystal display panel, it is necessary to check the change in the circuit characteristics during the process. For this reason, as shown in FIG. **1**, a testing element group (TEG) **170** is formed on the outside of the terminal portion **150**. The characteristics of the TFT and the like are checked by the TEG **170**. Thus, the TEG **170** should also have the same structure as the display area **10** or the drive circuit portion.

[0064] Also in the TEG **170**, the common electrode **110** of ITO is formed on the organic passivation film **109**. Then, the second interlayer insulating film **111** is present on the common electrode **110**. This is the same as in the display area **10** and the like. FIG. **5** is an example of the TEG **170**, in which a long resistance is formed between terminals **1501** and **1502** to measure the resistance formed by the common electrode **110**. Although not shown, the second interlayer insulating film **111** is formed on this long resistance. The common electrode **110** is formed on the organic passivation film **109**. When the water is released from the organic passivation film **109**, the second interlayer insulating film **111** peels off, and it is no longer able to function as the TEG **170**. In this embodiment, as shown in FIG. **5**, a large number of rectangular through holes **140** for gas release are formed to allow gas to be easily released from the organic passivation film **109**. In this way, the second insulating film **111** is prevented from peeling off.

[0065] FIG. **6** is a cross-sectional view taken along line B-B in FIG. **5**. The first and second base films are omitted in FIG. **6**. FIG. **6** shows that the semiconductor layer **103**, the gate insulating film **104**, the first interlayer insulating film **106**, the inorganic passivation film **108**, and the organic passivation film **109** are laminated in this order from the bottom. Then, the common electrode **110** is formed on the organic passivation film **109**. The second interlayer insulating film **111** is formed on the common electrode **110**. The through holes **140** for gas release are formed in the second interlayer insulating film **111**, in order that the water and the like can be easily released from the organic passivation film **109**. As a result, the second interlayer insulating film **111** is prevented from peeling off.

[0066] The manufacturing process of liquid crystal display devices is as follows. A mother board is formed by bonding a mother TFT board in which a large number of the TFT substrates **100** are formed, to a mother counter board in which a large number of the counter substrates **200** are formed. Then, individual liquid crystal display panels are cut out of the mother board by scribing or other method. When the mother TFT substrate and the mother counter substrate are bonded together by a sealing material, it is necessary to use the alignment mark **180**.

[0067] FIG. **7** is an example of an alignment mark **180**. In FIG. **7**, the alignment mark **180** is formed by combining square units. The rectangular through holes **140** for gas release are present in some of the units of the alignment mark **180**. The through holes **140** are formed in the second interlayer insulating film **111**. The through holes **140** for gas release allow the water and the like absorbed by the organic passivation film **109** to be easily released. As a result, the second interlayer insulating film **111** is prevented from peeling off.

[0068] FIG. **8** is a cross-sectional view taken along line C-C in FIG. **7**. The configuration of FIG. **8** is the same as that described with reference to FIG. **6**, except that the semiconductor layer **103** is not present. Thus, the description thereof will be omitted. Note that FIG. **6** or FIG. **8** is an example of the cross section. It does not necessarily mean that the semiconductor layer **103** is typically present in FIG. **6**, and that the semiconductor layer **103** is typically not present in FIG. **8**.

[0069] As described above, when the organic passivation film **109** and the second interlayer insulating film **111** are also formed in the area other than the area in which the liquid crystal is injected in the liquid crystal display panel, the through holes **140** for gas release are also formed in this area of the second interlayer insulating film **111**, to be able to function as the TEG **170** or the alignment mark **180** without fail. However, the TEG **170** or the alignment mark **180** shown in FIG. **1** is not used after the liquid crystal display device is completed. Thus, the portion of the TEG **170** or the alignment mark **180** is often removed in the scribing process. Note that also in this embodiment, the through hole **140** for gas release formed in the second interlayer insulating film is not covered by ITO. Thus, it is possible to release gas from the organic passivation film to the outside more effectively.

[0070] In the above examples, the IPS is the type in which the common electrode **110** is formed on the organic passivation film **109**, on which the pixel electrode **112** having the slit **115** is formed through the second interlayer insulating film **111**. However, the present invention can also be applied in the same way to the other types of IPS in which the pixel electrode **112** is formed on the organic passivation film **109**, on which the common electrode having the slit **115** is provided through the interlayer insulating film **111**.

What is claimed is:

1. A liquid crystal display device comprising a pixel electrode in an area surrounded by scan lines extending in a first

direction and arranged in a second direction and by image signal lines extending in the second direction and arranged in the first direction,

wherein the pixel electrode is supplied with an image signal from the image signal line through a TFT,

wherein the TFT includes a semiconductor layer having a channel portion, a drain portion formed on the side of the image signal line, and a source portion formed on the side of the pixel electrode,

wherein a gate insulating film is formed so as to cover the semiconductor layer,

wherein a gate electrode is formed on the gate insulating film above the channel portion,

wherein a first interlayer insulating film is formed so as to cover the gate electrode,

wherein the image signal line is provided on the first interlayer insulating film,

wherein an organic film is formed to cover the image signal line,

wherein a common electrode, which is a transparent electrode, is formed on the organic film,

wherein a second interlayer insulating film is formed on the common electrode,

wherein the pixel electrode, which is a transparent electrode, having a slit is formed on the second interlayer insulating film,

wherein a portion of the image signal line connected to the drain portion of the TFT has a width which is greater than a width of an other portion of the image signal line,

wherein the image signal line is connected in the greater width portion to the drain portion through a contact hole,

wherein a through hole is formed in the second interlayer insulating film in the greater width portion of the image signal line, and

wherein the diameter of the through hole is greater than the diameter of the contact hole.

2. The liquid crystal display device according to claim **1**,

wherein the TFT includes a first TFT and a second TFT,

wherein the first TFT has a drain portion connected to the image signal line,

wherein the second TFT is connected to the first TFT and has a source portion connected to the pixel electrode, and

wherein the scan line also functions as the gate electrodes of the first TFT and the second TFT.

3. The liquid crystal display device according to claim **1**, wherein the through hole formed in the second interlayer insulating film is not covered by the transparent electrode.

4. A liquid crystal display device comprising a pixel electrode formed in an area surrounded by scan lines extending in a first direction and arranged in a second direction and by image signal lines extending in the second direction and arranged in the first direction,

wherein the pixel electrode is supplied with an image signal from the image signal line through a TFT,

wherein the TFT includes a semiconductor layer having a channel portion, a drain portion formed on the side of the image signal line, and a source portion formed on the side of the pixel electrode,

wherein a gate insulating film is formed so as to cover the semiconductor layer,

wherein a gate electrode is formed on the gate insulating film above the channel portion,

wherein a first interlayer insulating film is formed so as to cover the gate electrode,

wherein the image signal line is provided on the first interlayer insulating film,

wherein an organic film is formed to cover the image signal line,

wherein the pixel electrode, which is a transparent electrode, is formed on the organic film,

wherein a second interlayer insulating film is formed on the pixel electrode,

wherein a common electrode, which is a transparent electrode, having a slit is formed on the second interlayer insulating film,

wherein a portion of the image signal line connected to the drain portion of the TFT has a width which is greater than a width of an other portion of the image signal line,

wherein the image signal line is connected in the greater width portion to the drain portion through a contact hole,

wherein a through hole is formed in the second interlayer insulating film in the greater width portion of the image signal line, and

wherein the diameter of the through hole is greater than the diameter of the contact hole.

5. The liquid crystal display device according to claim **4**,

wherein the TFT includes a first TFT and a second TFT,

wherein the first TFT has a drain portion connected to the image signal line,

wherein the second TFT is connected to the first TFT and has a source portion connected to the pixel electrode, and

wherein the scan line also functions as the gate electrodes of the first TFT and the second TFT.

6. The liquid crystal display device according to claim **4**, wherein the through hole formed in the second interlayer insulating film is not covered by the transparent electrode.

7. A liquid crystal display device comprising a display area and a peripheral circuit portion,

wherein the peripheral circuit portion includes a TFT including a semiconductor layer having a channel portion, a source portion, and a drain portion,

wherein a gate insulating film is formed so as to cover the semiconductor layer,

wherein a gate electrode is formed on the gate insulating film above the channel portion,

wherein a first interlayer insulating film is formed so as to cover the gate electrode,

wherein a metal line is formed on the first interlayer insulating film,

wherein the metal line is connected to the drain portion or the source portion through a contact hole formed in the first interlayer insulating film and in the gate insulating film,

wherein an organic film is formed to cover the metal line,

wherein a line of ITO is formed on the organic film,

wherein a second interlayer insulting film is formed on the ITO line,

wherein a through hole is formed in the second interlayer insulating film, and

wherein the diameter of the through hole is greater than the diameter of the contact hole.

8. The liquid crystal display device according to claim **7**, wherein the through hole formed in the second interlayer insulating film is not covered by ITO.

9. A liquid crystal display device comprising a TFT substrate and a counter substrate,

wherein the TFT substrate and the counter substrate are bonded face-to-face with a liquid crystal layer formed inside,

wherein a terminal portion and an alignment mark are formed in a portion of the TFT substrate not facing the counter substrate,

wherein the alignment mark is configured such that a gate insulating film, a first interlayer insulating film, and an organic film are laminated in this order on the TFT substrate,

wherein a transparent electrode is formed on the organic film,

wherein a second interlayer insulating film is formed on the transparent electrode, and

wherein a through hole is formed in the second interlayer insulating film in an area in which the alignment mark is formed.

10. The liquid crystal display device according to claim **9**, wherein the through hole formed in the second interlayer insulating film is not covered by the transparent electrode.

* * * * *

patsnap

专利名称(译)	液晶显示装置		
公开(公告)号	US20140043555A1	公开(公告)日	2014-02-13
申请号	US14/056545	申请日	2013-10-17
[标]申请(专利权)人(译)	株式会社日本显示器		
申请(专利权)人(译)	JAPAN DISPLAY INC		
当前申请(专利权)人(译)	日本展示INC.		
[标]发明人	NAKAMURA TAKAO ISHII KAZUKI MUTOU DAISUKE SEKI HIDENORI		
发明人	NAKAMURA, TAKAO ISHII, KAZUKI MUTOU, DAISUKE SEKI, HIDENORI		
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摘要(译)

在使用TFT的液晶显示装置中，形成接触孔以连接图像信号线。形成有机膜以覆盖图像信号线，并且在有机膜上形成作为透明电极的公共电极。在公共电极上形成层间绝缘膜。在层间绝缘膜中形成通孔，并且通孔的直径大于接触孔的直径。