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(54) **LIQUID CRYSTAL DISPLAY DEVICE**

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(30) **Foreign Application Priority Data**

Sep. 29, 2011 (JP) 2011-213981

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G02F 1/1368	(2006.01)

(52) **U.S. Cl.**

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(57) **ABSTRACT**

In a liquid crystal display device, there is provided a liquid crystal display panel in which a TFT substrate and a counter substrate are bonded together by a sealing material, with a liquid crystal sandwiched between the substrates. Further, a front window with a black border print formed in the periphery is bonded to the liquid crystal display panel by a UV curable resin. The liquid crystal is filled by a drop method. The thickness of the TFT substrate and the counter substrate is reduced to about 0.2 mm by polishing. An inner end of the black border print of the front window is inside an inner end of the sealing material, to prevent the counter substrate of the liquid crystal display panel from being deformed by stress generated in the curing of the UV curable resin, thereby preventing yellow discoloration in the periphery of the display area.

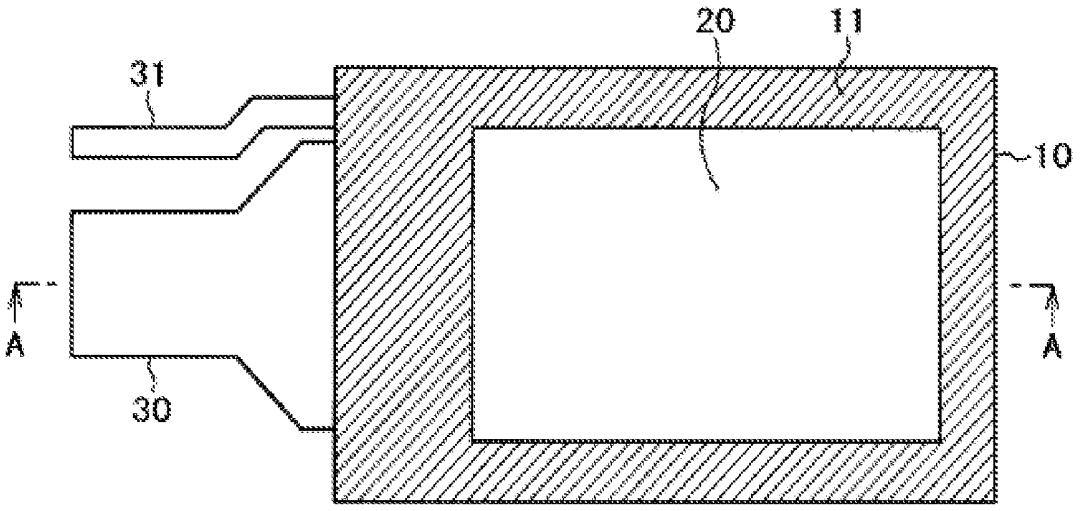


FIG. 1

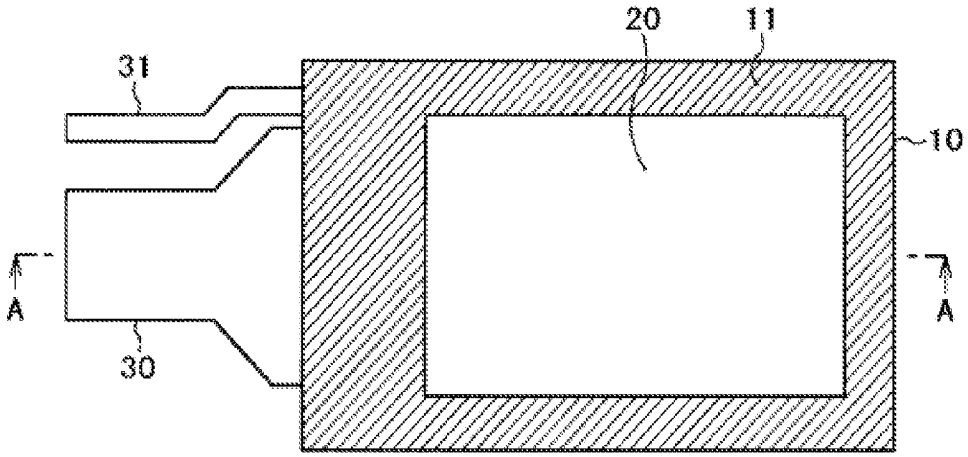


FIG. 2

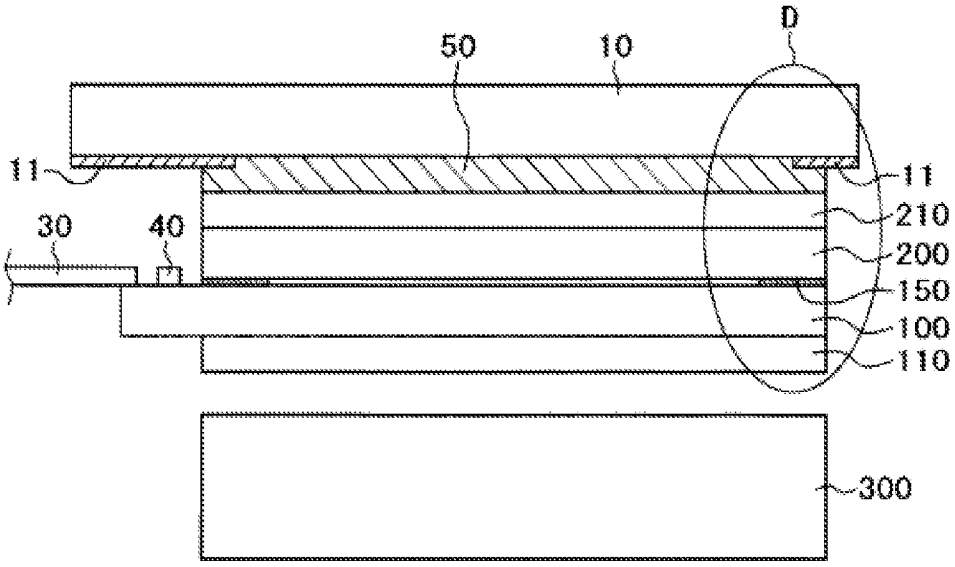


FIG. 3

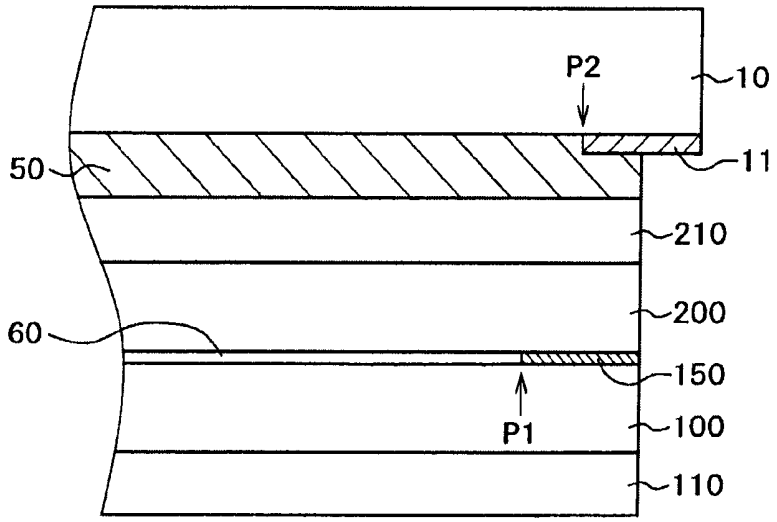
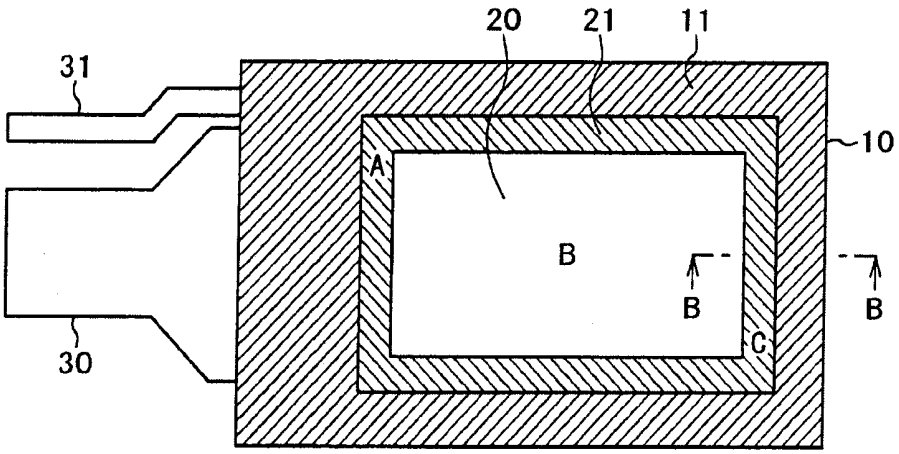
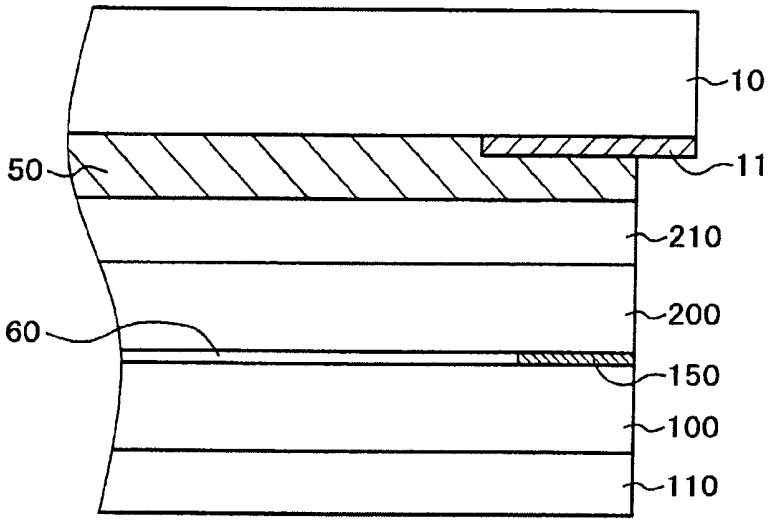


FIG. 4



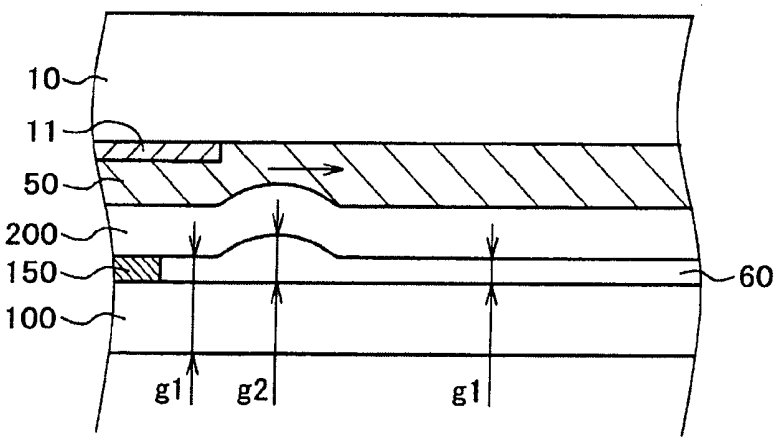
Prior Art

FIG. 5



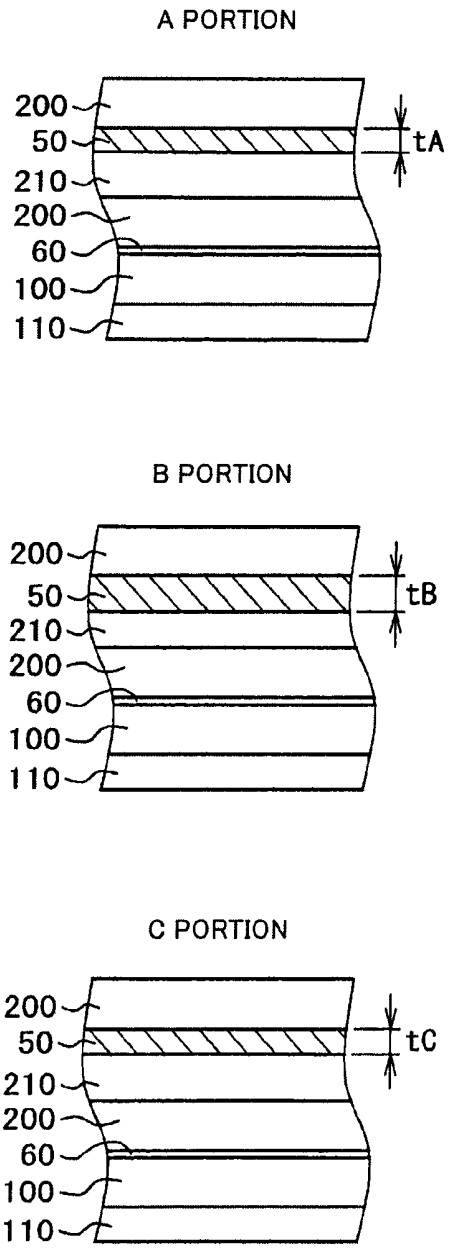
Prior Art

FIG. 6



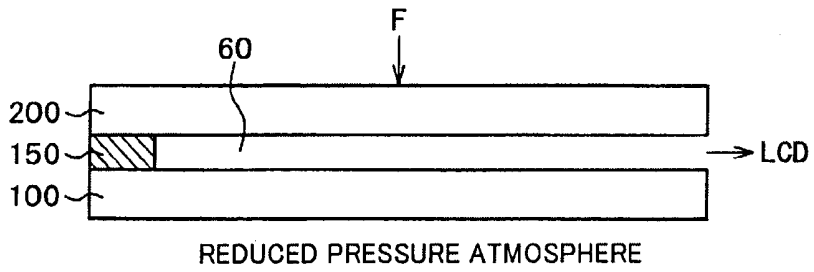
Prior Art

FIG. 7



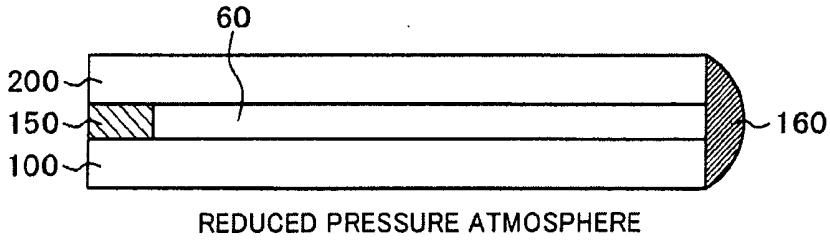
Prior Art

FIG. 8A



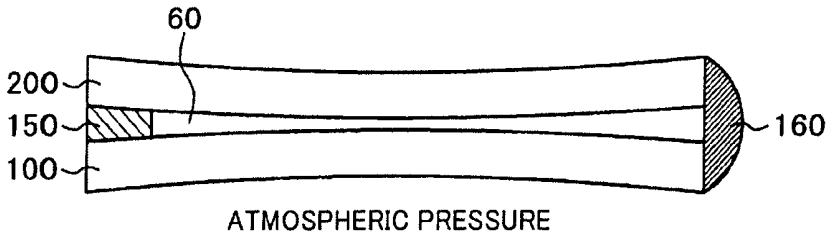
Prior Art

FIG. 8B



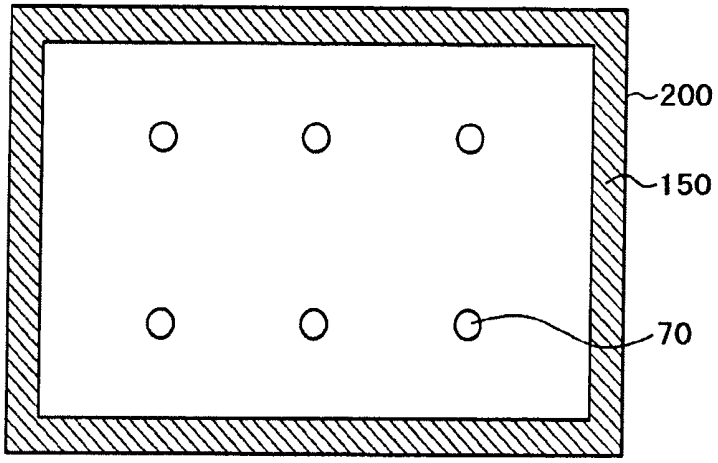
Prior Art

FIG. 8C



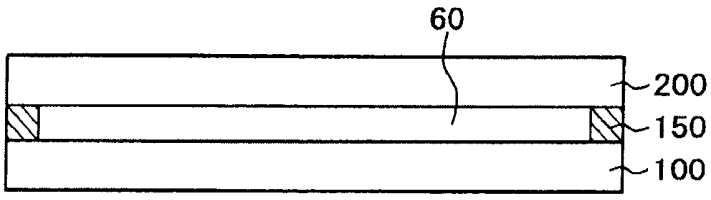
Prior Art

FIG. 9A



Prior Art

FIG. 9B



Prior Art

LIQUID CRYSTAL DISPLAY DEVICE

CLAIM OF PRIORITY

[0001] The present application is a continuation of U.S. patent application Ser. No. 13/601,196, filed on Aug. 31, 2012, which claims priority from Japanese Patent Application JP 2011-213981 filed on Sep. 29, 2011. The entire disclosures of each of these applications are hereby incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to a liquid crystal display device, and more particularly to a small display device including a front window.

BACKGROUND OF THE INVENTION

[0003] In a liquid crystal display device, there is provided a TFT substrate in which pixel electrodes, thin film transistors (TFT) and the like are arranged in a matrix form. Further, a counter substrate is disposed opposite to the TFT substrate. In the counter substrate, color filters and the like are formed at locations corresponding to the pixel electrodes of the TFT substrate. Then, a liquid crystal is sandwiched between the TFT substrate and the counter substrate. Thus, the liquid crystal display device forms an image by controlling the transmittance of light of the liquid crystal molecules for each pixel.

[0004] Regarding the liquid crystal display device, there is a strong demand for reducing the overall size of the set itself and reducing the thickness of the liquid crystal display panel, with the size of the screen being fixed. In order to reduce the thickness of the liquid crystal display panel, the liquid crystal display panel is formed and thinned by polishing the outside.

[0005] The TFT substrate including pixel electrodes, TFT and the like, and the counter substrate including color filters, are glass substrates constituting the liquid crystal display device. The two glass substrates are standardized, for example, at a thickness of 0.5 mm or 0.7 mm. It is difficult to obtain glass substrates, other than such standardized substrates, from the market. In addition, very thin glass substrates have a problem in the production process in terms of mechanical strength and bending or deformation, which reduces the production yield. For this reason, the liquid crystal display panel is formed by the standardized glass substrates and is thinned by polishing the external surface of the liquid crystal display panel.

[0006] When the thickness of the liquid crystal display device is reduced, there is a problem of mechanical strength. If mechanical stress is applied to the display surface of the liquid crystal display panel, the liquid crystal display panel may be destroyed. In order to prevent this, a front window is attached to the side of the screen of the liquid crystal display panel when the liquid crystal display panel is mounted to a cellular phone set and the like.

[0007] In general, the front window is attached to the liquid crystal display panel with a UV curable resin. In order to improve design quality and image quality, as well as other improvements, a black border is printed around the front window. Ultraviolet light does not easily pass through the portion of the black border print, so that non-uniformity occurs in the UV curable resin.

[0008] Japanese Unexamined Publication No. 2009-192792 describes a method of curing the UV curable resin under the black border print by using the gradient the black border print, in order to eliminate the non-uniformity in the degree of curing of the UV curable resin. In other words, in Japanese Unexamined Publication No. 2009-192792, the area of the black border print is divided into two parts: one is the inner part where the color is light, and the other is the outer part where the color is deep. With this configuration, it is possible to prevent the stress in the curing of the resin.

SUMMARY OF THE INVENTION

[0009] However, in the technology described in Japanese Unexamined Publication No. 2009-192792, it is found that the stress generated on the glass substrate is not necessarily reduced and may increase the difference in the degree of curing of the UV curable resin. Further, the black border print is formed to increase the display quality level. However, there is also a problem that the screen is dims down when the blackening degree in the inner part of the black border print is low.

[0010] It is desirable that in a liquid crystal display device including a liquid crystal display panel to which a front window with a black border print is attached, yellow discoloration or other damage is prevented from occurring in the periphery of the display area of the liquid crystal display panel, by reducing the deformation due to the stress generated particularly on a counter substrate when an adhesive is cured onto the liquid crystal display panel.

[0011] The present invention is to solve the above problem. An example of one aspect of the present invention is as follows. There is provided a liquid crystal display device including a liquid crystal display panel to which a front window is attached. The liquid crystal display panel includes a TFT substrate in which pixels each having a pixel electrode and a TFT are formed, and a counter substrate in which color filters are formed. The TFT substrate and the counter substrate are bonded together by a sealing material. A liquid crystal is filled between the TFT substrate and the counter substrate. A lower polarization plate is attached to the side of the TFT substrate. Then, an upper polarization plate is attached to the side of the counter substrate. A black border is printed around the front window. The side of the front window in which the black border is printed is bonded to the upper polarization plate of the liquid crystal display panel by a UV curable resin. An inner end portion of the sealing material is formed in an inside of the inner end portion of the black border print of the front window.

[0012] In the liquid crystal display panel described above, preferably the inner end portion of the sealing material is 0.2 mm or more inside from the inner end portion of the black border print of the front window.

[0013] According to the present invention, it is possible to prevent the deformation of the counter substrate due to the curing shrinkage of the UV curable resin, in the liquid crystal display device in which the liquid crystal display panel and the front window are bonded together by the UV curable resin. Thus, it is possible to prevent yellow discoloration from occurring in the periphery of the display area.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is a plan view of a liquid crystal display device to which the present invention is applied;

[0015] FIG. **2** is a cross-sectional view taken along line A-A of FIG. **1**;

[0016] FIG. **3** is an enlarged view of a D portion in FIG. **2**;

[0017] FIG. **4** is a schematic plan view of yellow discoloration in the periphery of the display area in the liquid crystal display device;

[0018] FIG. **5** is a cross-sectional view showing the position of a black border print in the front window as well as the position of a sealing material in the liquid crystal display panel in the related art;

[0019] FIG. **6** is a schematic cross-sectional view of the state in which the counter substrate of the liquid crystal display panel is deformed by the UV curable resin;

[0020] FIG. **7** is cross-sectional views showing that the thickness of the UV curable resin is different depending on the location;

[0021] FIGS. **8**A, **8**B, and **8**C are views of the process of filling liquid crystal by vacuum suction; and

[0022] FIGS. **9**A and **9**B are views of the process of filling liquid crystal by a drop method.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] Before the description of embodiments of the present invention, the problem occurred in the liquid crystal display device to which the present invention is applied will be described. FIG. **4** is a plane view of a liquid crystal display device used for cellular phones or other electronic devices. In FIG. **4**, a front window **10** is provided on the surface. A black border print **11** is formed in the periphery of the front window **10**. The inside of the black border print is a display area **20**. In FIG. **4**, a liquid crystal display panel provided below the front window **10** is smaller than the front window **10**, so that the liquid crystal display panel does not appear in FIG. **4**. Then, a flexible wiring substrate **30** connected to the liquid crystal display panel as well as a backlight flexible wiring substrate **31** extend on the left side of FIG. **4**.

[0024] In FIG. **4**, a yellow discolored area **21** is present around the display area **20**, namely, in the inner part of the black border print **11**. As described later, the yellow discolored area **21** is generated by the fact that the gap between the TFT substrate **100** and the counter substrate **200** increases in the liquid crystal display panel.

[0025] FIG. **5** is a cross-sectional view taken along line B-B of FIG. **4**. In FIG. **5**, a liquid crystal layer **60** is sandwiched between the TFT substrate **100** and the counter substrate **200**. The liquid crystal layer **60** is sealed by a sealing material **150** formed in the periphery of the TFT substrate **100** and the counter substrate **200**. The width of the sealing material **150** is about 0.8 mm. A lower polarization plate **110** is attached to the lower side of the TFT substrate **100**. Then, an upper polarization plate **210** is attached to the upper side of the counter substrate **200**.

[0026] The front window **10** is bonded to the upper polarization plate **210** through an adhesive **50**. The black border print **11** is formed in the lower periphery of the front window **10**. The width of the black border print **11** in the short side where the flexible wiring substrate is not connected is about 10 mm. The adhesive **50** is a UV curable resin. The UV curable resin is initially a liquid that contains, for example, 27% to 30% acrylic oligomer. It is also possible to use acrylic resin containing UV reactive monomer or additive agent for photopolymerization and the like. In this case, the thickness of the adhesion can be about several μm to 30 μm.

[0027] During curing of the UV curable resin **50**, curing shrinkage occurs. The curing shrinkage of the adhesive **50** occurs in the direction shown in the arrow of FIG. **6**. Thus, the thickness of the adhesive **50** in the periphery is smaller than in the center. For example, FIGS. **7**A, **7**B, and **7**C show the film thickness of the adhesive in positions A, B, and C in FIG. **4**. In FIG. **7**, an adhesive thickness tA in the position A in the periphery is 53 μm, an adhesive thickness tB in the position B in the center is 72 μm, and an adhesive thickness tC in the position C in the periphery is 54 μm. Because the thickness of the adhesive differs in this way, stress occurs particularly on the counter substrate **200** of the liquid crystal display panel. As a result, deformation occurs in the counter substrate **200** as shown in FIG. **6**.

[0028] FIG. **6** is a schematic view of the influence of the curing shrinkage of the UV curable resin **50**. FIG. **6** is a schematic view, so that the upper polarization plate **210** and the lower polarization plate **110** are omitted. However, the influence of the curing shrinkage of the UV curable resin **50**, which will be described below, reaches the counter substrate **200** of the liquid crystal display panel through the upper polarization panel **210**. In FIG. **6**, the arrows indicate the direction of the curing shrinkage of the UV curable resin **50**. Thus, the thickness of the adhesive **50** in the center is greater than in the periphery.

[0029] The counter substrate **200** of the liquid crystal display panel is deformed as shown in FIG. **6** by the stress due to the difference in the thickness of the adhesive **50**. As a result, the gap between the counter substrate **200** and the TFT substrate **100** increases in the area where the counter substrate **200** is deformed. For example, the gap between the counter substrate **200** and the TFT substrate **100** is 4 μm, but is 4.4 μm in the area where the gap increases due to the deformation of the counter substrate **200**. This is the cause of the yellow discolored area **21** in the periphery of the substrate shown in FIG. **4**. Note that the deformation of the counter substrate **200** occurs not only by the difference in the thickness of the adhesive **50** but also the difference in the degree of curing by ultraviolet light passing through the black border print **11** on the front window **10**.

[0030] The deformation of the counter substrate **200** shown in FIG. **6** is not likely to occur in the liquid crystal display panel formed by vacuum filling of liquid crystal shown in FIGS. **8**A, **8**B, and **8**C. In the vacuum filling of liquid crystal shown in FIGS. **8**A, **8**B, and **8**C, liquid crystal is filled into the liquid crystal display panel. Then, a portion of the liquid crystal is taken out to the outside by a force F from the outside, so that the gap between the flat TFT substrate and the flat counter substrate is completely filled with the liquid crystal. Then, as shown in FIG. **8**B, the inlet of a liquid crystal **60** is sealed by a sealing material **160**. FIGS. **8**A and **8**B are performed in a reduced pressure atmosphere. After that, when the liquid crystal display panel is placed in the atmosphere, the TFT substrate **100** and the counter substrate **200** bend to the inside due to the atmospheric pressure as shown in FIG. **8**C. Because the TFT substrate **100** and the counter substrate **200** bend to the inside, the deformation shown in FIG. **6** is not likely to occur.

[0031] As an example of the filling method of the liquid crystal **60**, there is One Drop Fill (ODF) method. One Drop Fill (ODF) is the method for precisely controlling the amount of liquid crystal **70**, dropping the liquid crystal **70** into the counter substrate **200** in which the sealing material **150** is formed, and bonding the TFT substrate **100** and the counter substrate **200** to each other. The filling speed of the liquid crystal is faster in ODF than in the vacuum filling method.

However, the TFT substrate **100** or the counter substrate **200** does not bend to the inside and is flat as shown in FIG. **9**B. For this reason, the counter substrate **200** is likely to be deformed as shown in FIG. **6**.

FIRST EMBODIMENT

[0032] The present invention is particularly effective with respect to a liquid crystal display panel in which a liquid crystal **70** is filled by the ODF process shown in FIG. **9**. FIG. **1** is a plan view of a small liquid crystal display device such as a cellular phone to which the present invention is applied. FIG. **1** is the same as FIG. **4** except the yellow discolored area does not occur in the periphery of a display area **20**, and the description thereof will be omitted.

[0033] FIG. **2** is a cross-sectional view taken along line A-A of FIG. **1**. In FIG. **2**, it is shown a liquid crystal display panel in which a front window **10** is attached on a backlight **300**. In the backlight **300**, an LED which is a light source, a light guide panel, a reflective sheet, a diffusion sheet, a prism sheet and the like are placed, for example, in a resin mold. The liquid crystal display panel is placed on the resin mold.

[0034] In FIG. **2**, the liquid crystal display panel includes a TFT substrate **100**, a counter substrate **200**, a lower polarization plate **110**, and an upper polarization plate **210**. A liquid crystal layer is sandwiched between the TFT substrate **100** and the counter substrate **200**. The liquid crystal layer is sealed by a sealing material **150**. The sealing material is seamlessly formed in the entire circumference at a width of 0.8 mm. The thickness of the TFT substrate **100** and the counter substrate **200** is reduced from 0.5 mm to about 0.2 mm by polishing.

[0035] The liquid crystal is filled by the ODF process. In this case, the sealing material **150** is formed on the counter substrate **200**, and the liquid crystal is dropped into the counter substrate **200** by the drop method. Then, the counter substrate **200** is bonded to the TFT substrate **100**. The TFT substrate **100** is made larger than the counter substrate **200**. An IC driver **40** and a flexible wiring substrate **30** are connected to the end portion of the TFT substrate **100** where the counter substrate does not overlap the TFT substrate **100**.

[0036] A front window **10** is bonded to the upper polarization plate **210** attached to the counter substrate **200**, by an adhesive **50** of UV curable resin. A black border print **11** is formed in the periphery of the front window **10**. The width of the black border print is in the range of 0.5 mm to 10 mm. The feature of the present invention is that the inner end portion of the black border print **11** is inside the inner end portion of the sealing material **150** of the liquid crystal display panel.

[0037] FIG. **3** is an enlarged view of a D portion in FIG. **2**. In FIG. **3**, the front window **10** is attached to the liquid crystal display panel by the adhesive **50**. The liquid crystal display panel includes the TFT substrate **100**, the counter substrate **200**, the liquid crystal layer **60** sandwiched between the TFT substrate **100** and the counter substrate **200**, the sealing material **150** surrounding the liquid crystal display layer, the lower polarization plate **110** attached to the TFT substrate **100**, and the upper polarization plate **210** attached to the counter substrate **200**.

[0038] In FIG. **3**, the TFT substrate **100** and the counter substrate **200** are formed from glass. The thickness of each of the glass substrates is reduced to about 0.2 mm by polishing the outside. The thickness of both the upper polarization plate **210** and the lower polarization plate **110** is 0.13 mm. The total thickness of the counter substrate **200** and the polarization plate **210**, which is attached to the counter substrate **200**, is 0.66 mm. Thus, the counter substrate **200** is easily deformed by an external force.

[0039] The black border print **11** is formed in the lower periphery of the front window **10**. The liquid crystal display panel and the front window **10** are bonded together by the UV curable resin **50**. When the UV curable resin **50** is irradiated by ultraviolet light, curing shrinkage occurs. As a result, the film thickness of the adhesive **50** is reduced in the periphery of the liquid crystal display panel, and stress occurs in the counter substrate **200** of the liquid crystal display panel.

[0040] As the thickness of the counter substrate **200** is about 0.2 mm, so that the counter substrate **200** is easily deformed when the stress is applied. As a result, the gap between the TFT substrate **100** and the counter substrate **200** is changed as described with reference to FIG. **6**. The stress due to the curing shrinkage of the adhesive **50** is likely to occur particularly in the vicinity of the end of the black border print **11** of the front window **10**. When the deformation of the counter substrate **200** occurs on the lower side of the black border print **11**, discoloration can be prevented when color and the like is changed. However, when the deformation of the counter substrate **200** occurs inside the end of the black border print **11**, yellow or other screen discoloration is visible.

[0041] In the present invention, an inner end portion P**1** of the sealing material **150** is located inside an inner end portion P**2** of the black border print **11** of the front window **10**. Preferably, the inner end portion P**1** of the sealing material **150** is 0.2 mm or more inside from the inner end portion P**2** of the black border print **11** of the front window **10**. Further, in FIG. **2**, the inner end portion P**2** of the black border print **11** is present within the seal width in the thickness direction of the panel. In other words, the black border print **11** and the sealing material **150** are located so that the two regions partially overlap when viewed from the side of the front window.

[0042] In FIG. **3**, the sealing material **150** is an epoxy resin with a thickness of several μm, and has a very strong adhesive force. The TFT substrate **100** and the counter substrate **200** are tightly bonded by the sealing material **150** with very strong adhesive properties, so that the strength is equal to that of twice the layer thickness. As a result, the deformation with respect to the stress is reduced to one eighth.

[0043] As described above, according to the present invention, the sealing material **150** for bonding the TFT substrate **100** and the counter substrate **200** is formed at the location where the stress is the maximum, so that the counter substrate **200** is not likely to be deformed. Thus, the gap between the TFT substrate **100** and the counter substrate **200** can be kept constant.

What is claimed is:

1. A liquid crystal display device comprising:
a front window;
a liquid crystal display panel attached to the display panel comprising
a TFT substrate,
a counter substrate,
a liquid crystal disposed between the TFT substrate and the counter substrate,
a sealing material disposed between the TFT substrate and the counter substrate and sealing the liquid crystal,
a black border formed in the periphery of the front window,
a driver disposed on the TFT substrate and
a resin adhering to the front window;

wherein, in a plan view, a center of the display area is closer to an inner end portion of the sealing material than to an inner end portion of the black border;

wherein the resin adheres to the black border,

wherein the resin overlaps with the sealing material and the black border in a plan view and

wherein, in a plan view, the black border is disposed above the driver.

* * * * *

专利名称(译)	液晶显示装置		
公开(公告)号	US20160109749A1	公开(公告)日	2016-04-21
申请号	US14/979849	申请日	2015-12-28
[标]申请(专利权)人(译)	株式会社日本显示器		
申请(专利权)人(译)	日本展示INC.		
当前申请(专利权)人(译)	日本展示INC.		
[标]发明人	TANABE SHINJI KOBAYASHI SETSUO ISHII KATSUHIKO ISHII AKIRA SENTO KIYOSHI		
发明人	TANABE, SHINJI KOBAYASHI, SETSUO ISHII, KATSUHIKO ISHII, AKIRA SENTO, KIYOSHI		
IPC分类号	G02F1/1335 G02F1/1339 G02F1/1345 G02F1/1368		
CPC分类号	G02F1/133512 G02F1/1368 G02F2001/133388 G02F1/13454 G02F1/1339 G02F1/133308 G02F2001/133331 G02F2001/133562 G02F2201/54 G02F2202/023 G02F2202/28		
优先权	2011213981 2011-09-29 JP		
其他公开文献	US9864226		
外部链接	Espacenet USPTO		

摘要(译)

在液晶显示装置中，提供了一种液晶显示板，其中TFT基板和相对基板通过密封材料结合在一起，液晶夹在基板之间。此外，在周边形成有黑色边缘印刷的前窗通过UV可固化树脂粘合到液晶显示板。通过滴落法填充液晶。通过抛光将TFT基板和对向基板的厚度减小到约0.2mm。前窗的黑色边框印刷的内端位于密封材料的内端内，以防止液晶显示面板的相对基板因紫外线固化树脂固化时产生的应力而变形，从而防止显示区域周围出现黄色变色。