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(54) LIQUID CRYSTAL DISPLAY DEVICE AND METHOD THEREOF

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(57) **ABSTRACT**

A dam is formed between drawing wires adjacent to each other. This dam is formed in the same step of forming a polymer layer having a displaying electrode thereon in the polymer film on an array(PFA)-type liquid crystal display device.

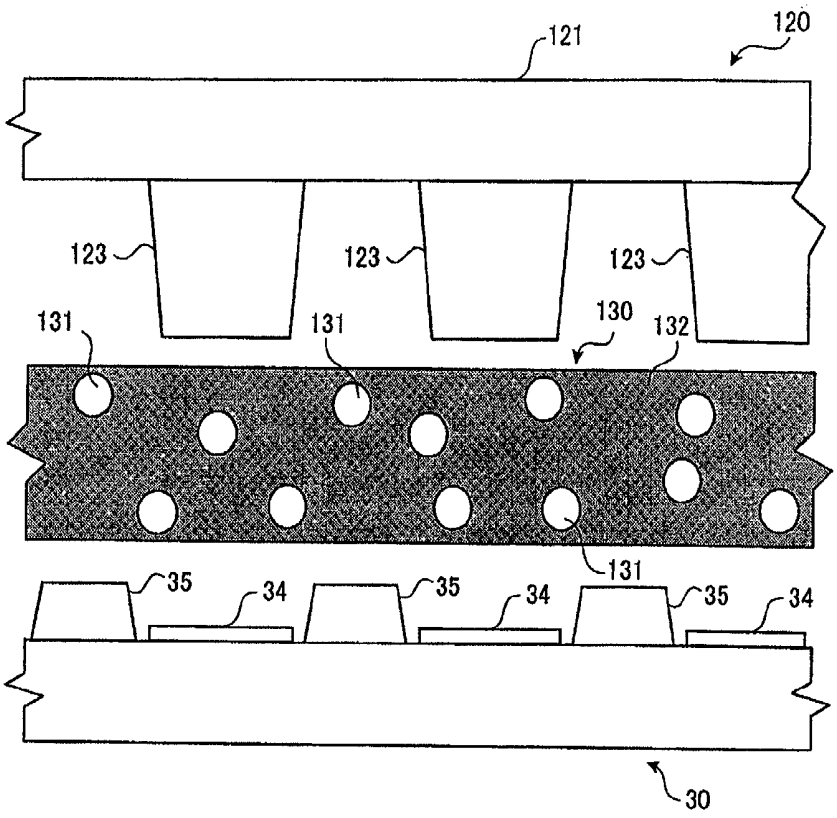


FIG. 1

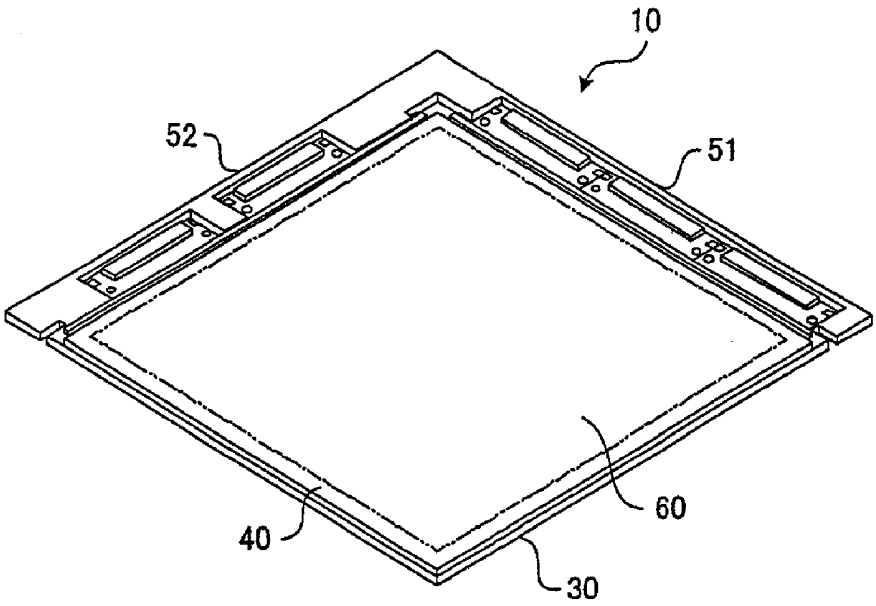


FIG. 2

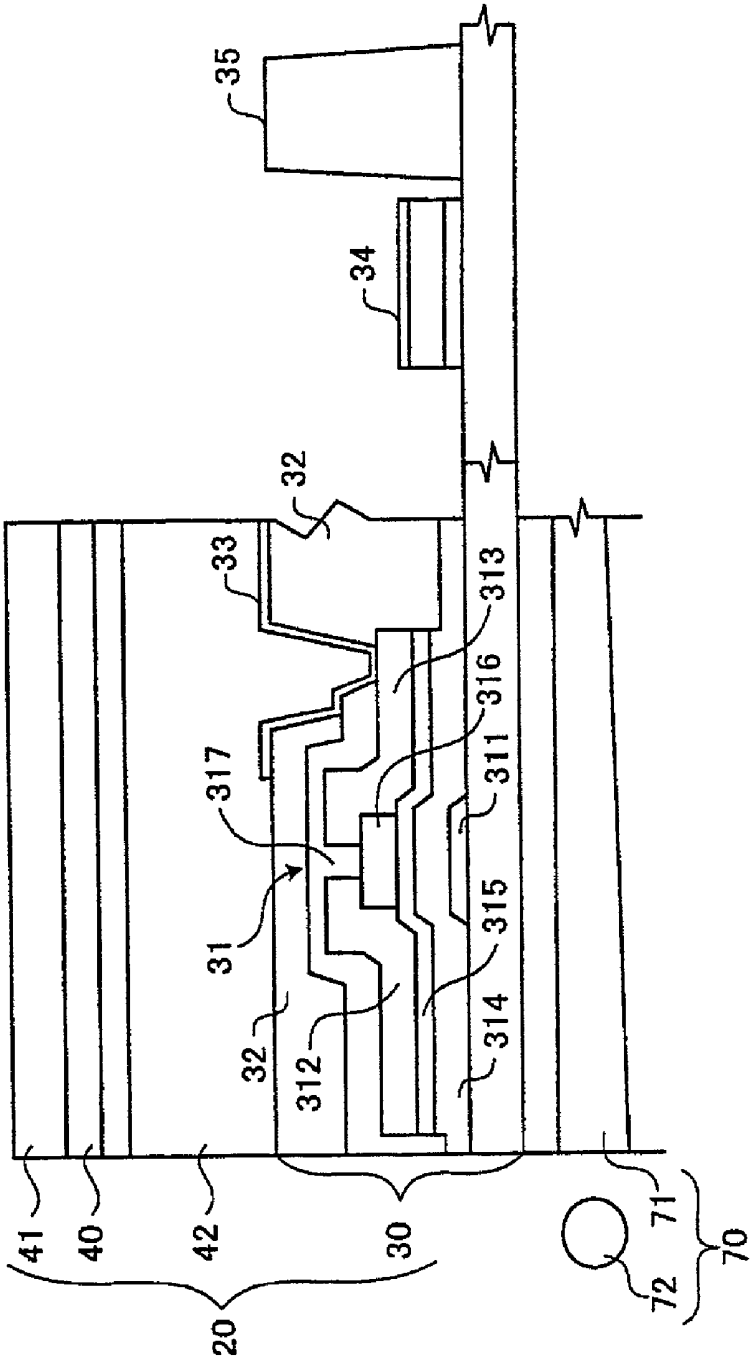


FIG. 3

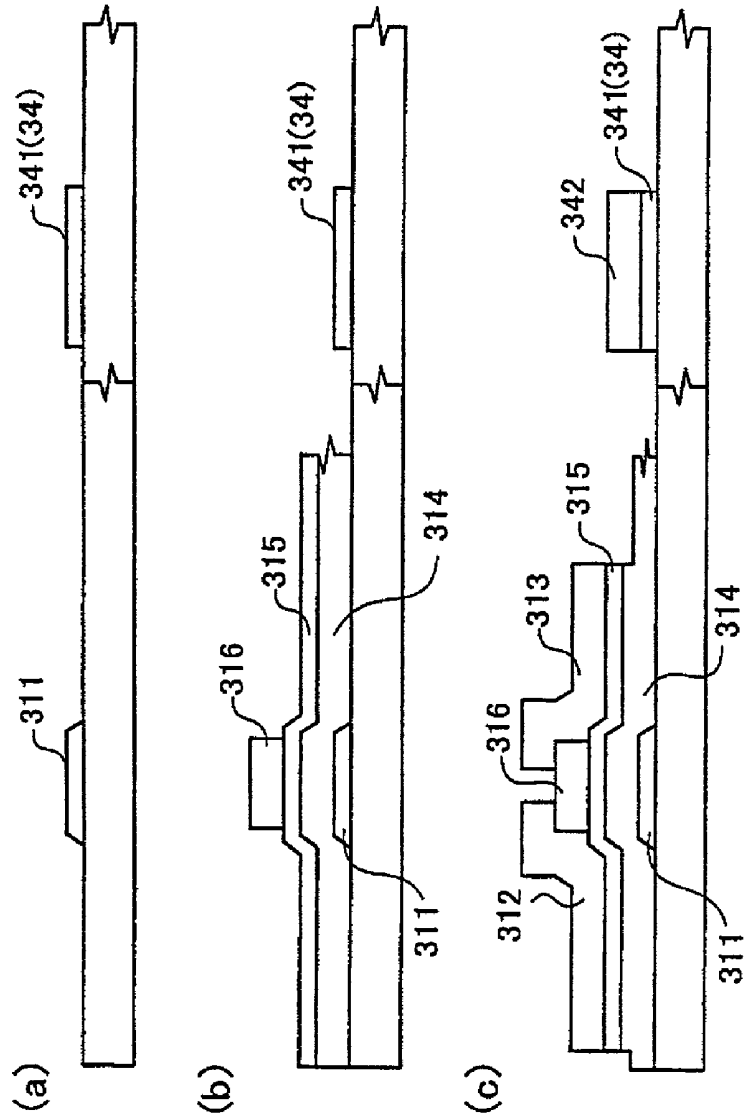
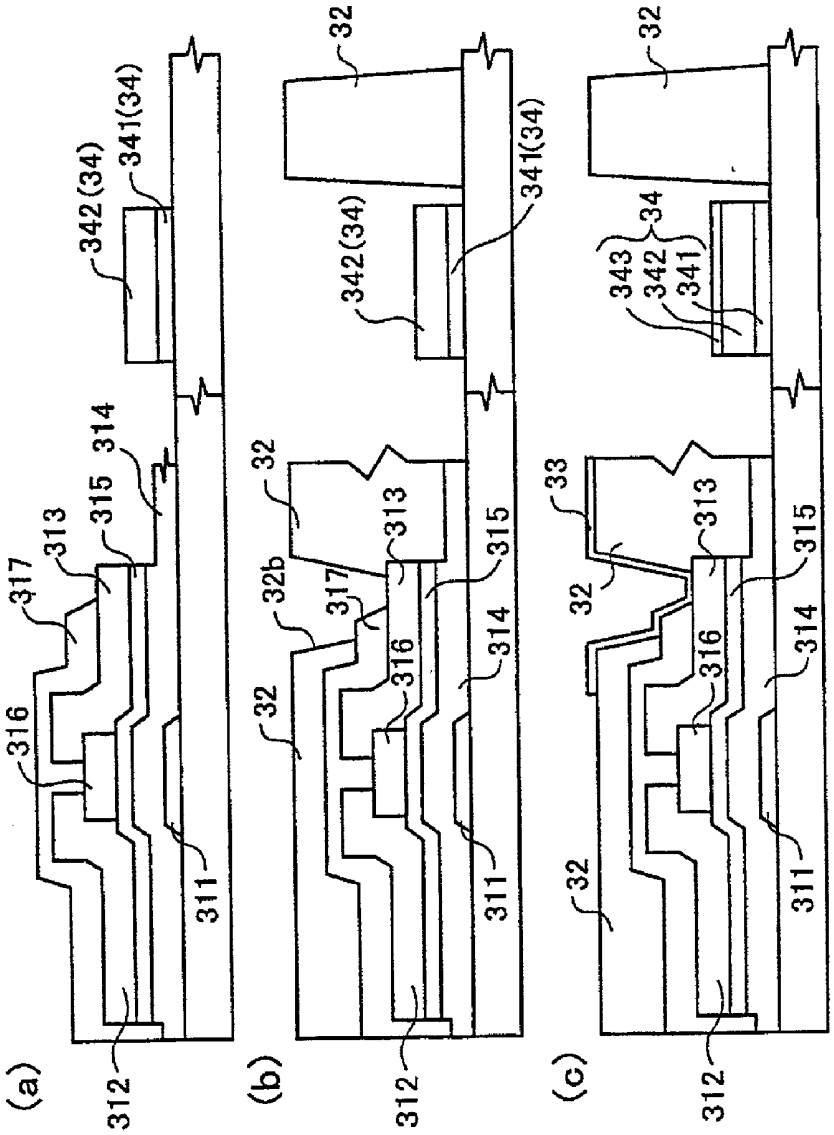

(a)
341(34)
311
(b)
341(34)
316
315
314
311
(c)
341(34)
342
315
313
314
316
312
311

FIG. 4


(a)
(b)
(c)
311
312
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314
315
316
317
32
32b
33
34
341
341(34)
342
342(34)
343

FIG. 5

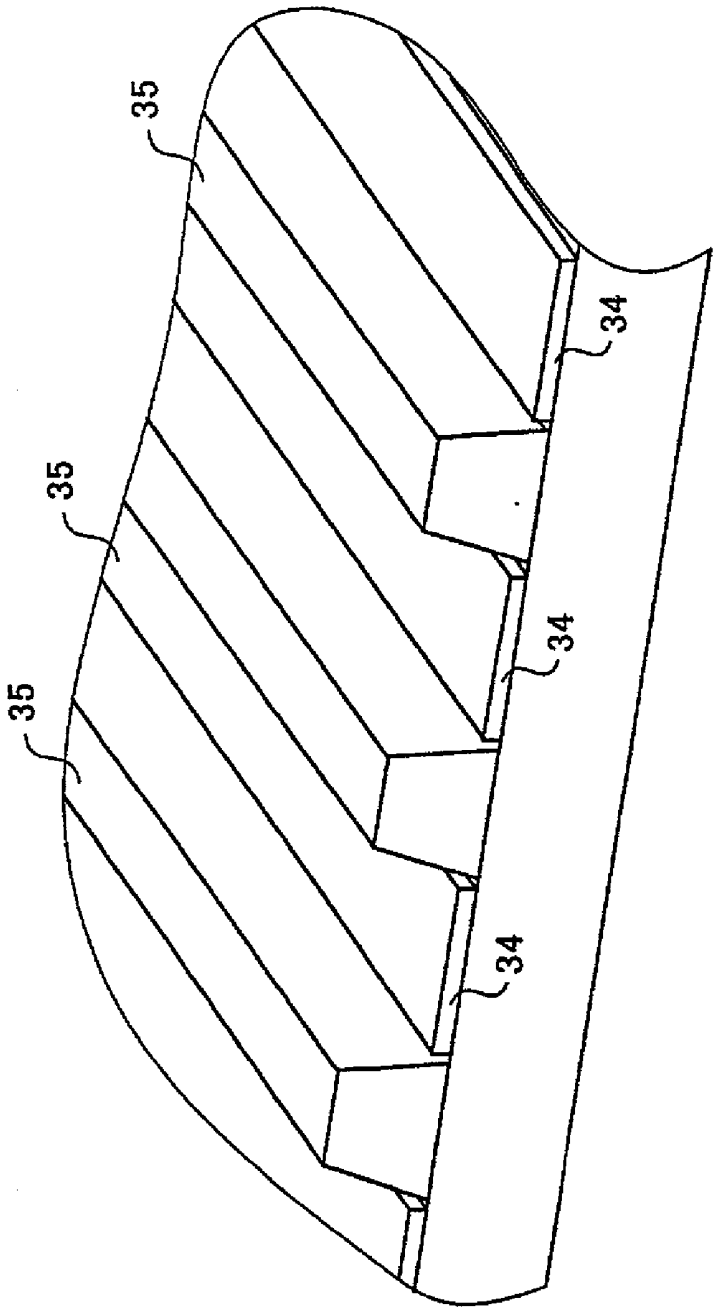


FIG. 6

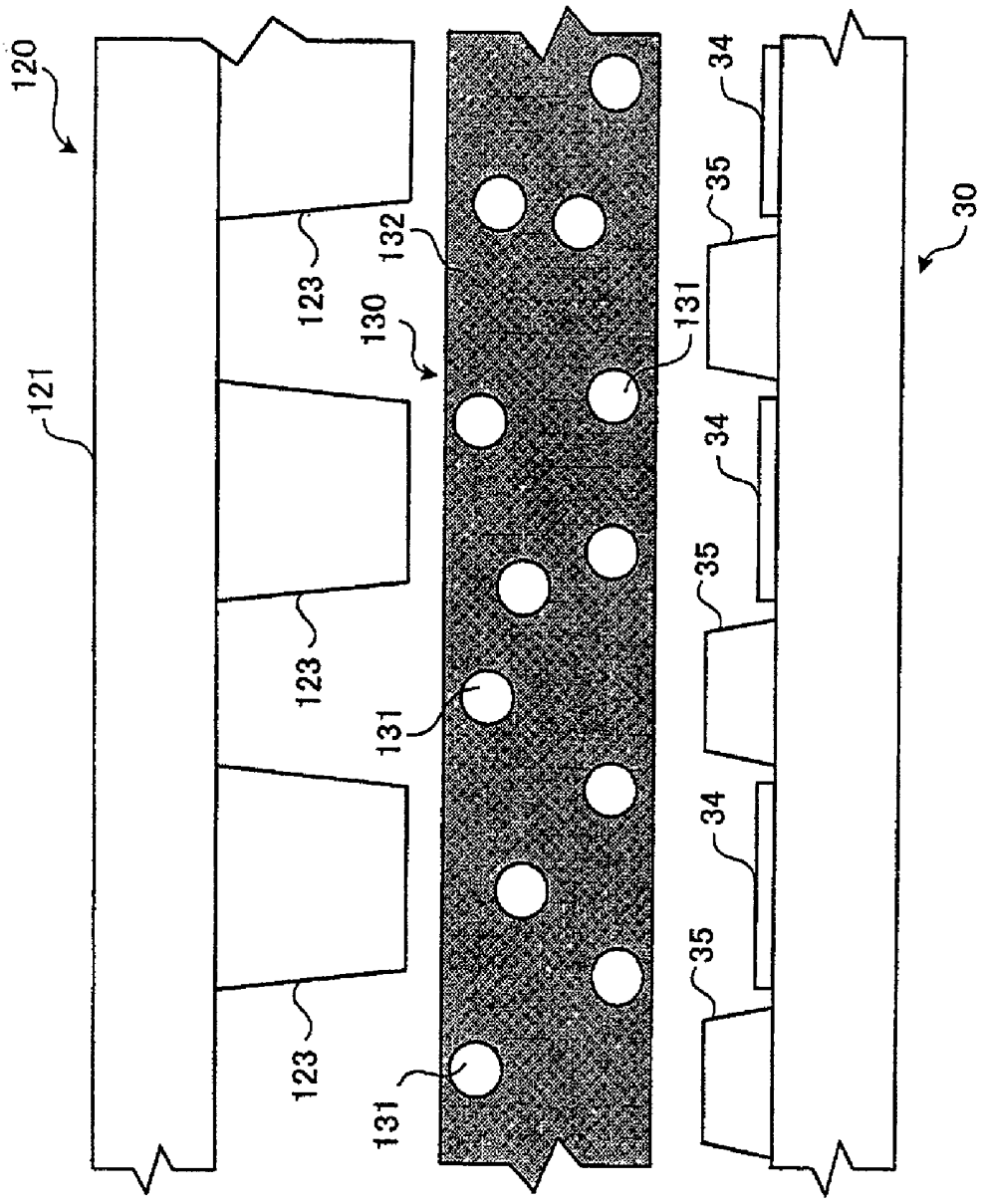


FIG. 7

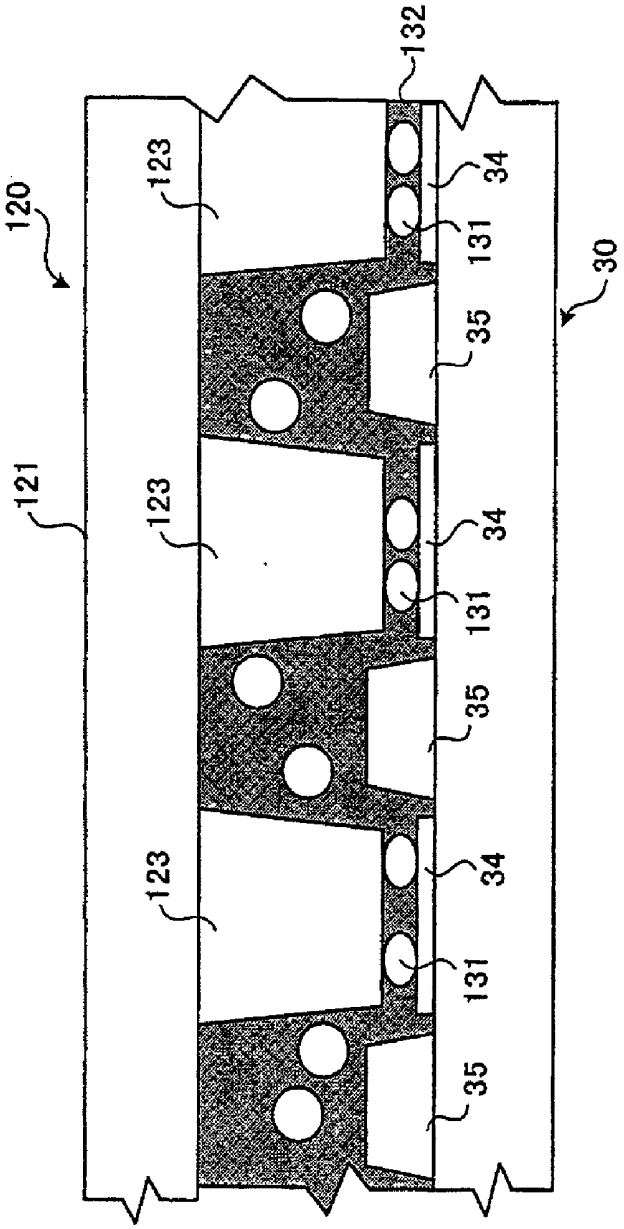


FIG. 8

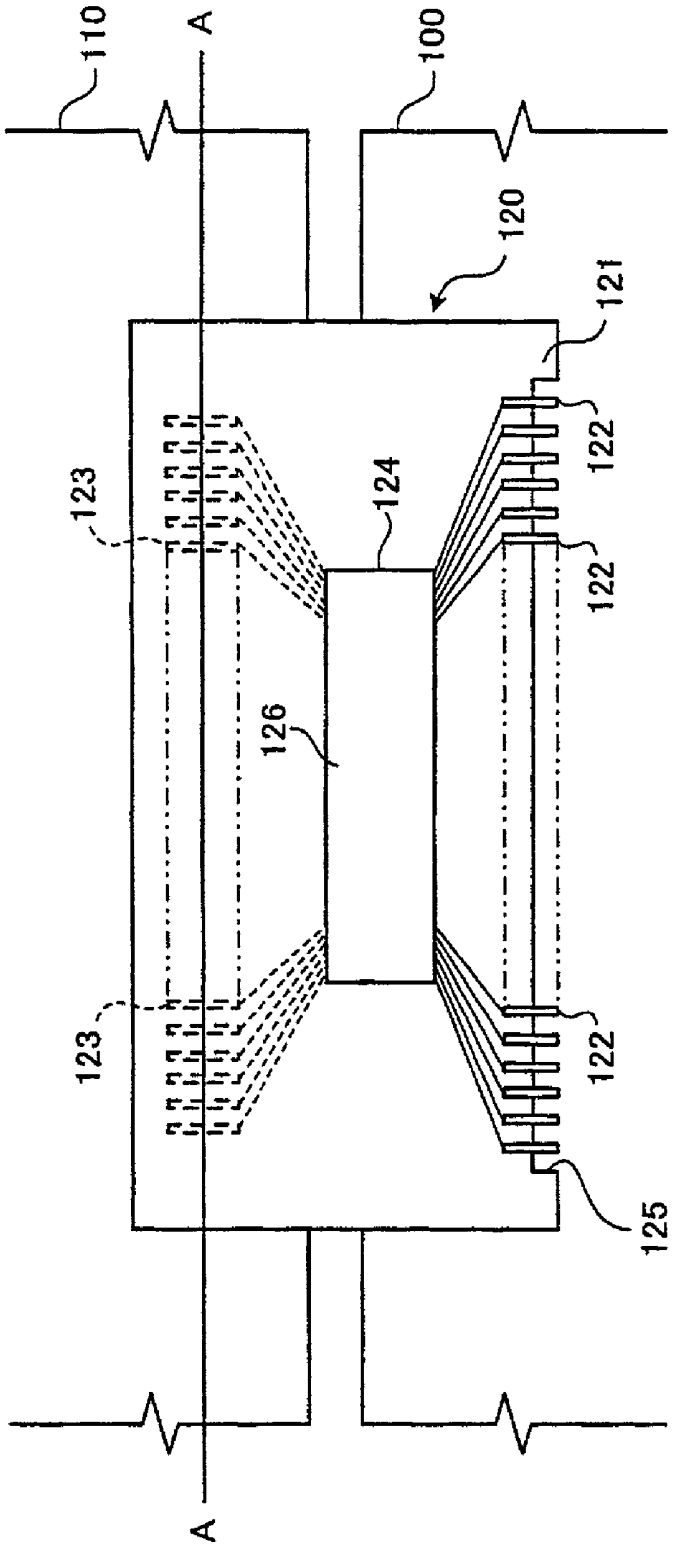


FIG. 9

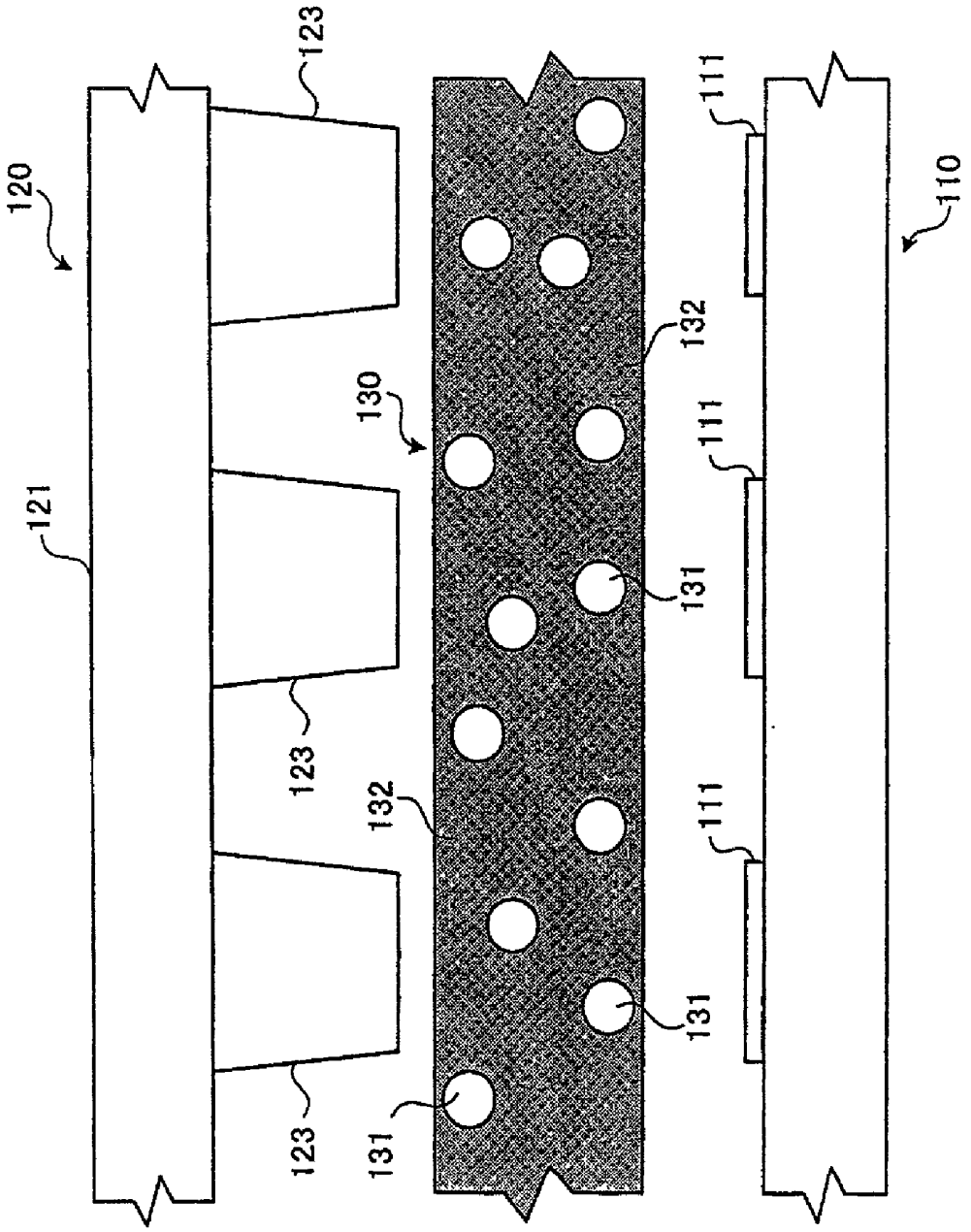


FIG. 10

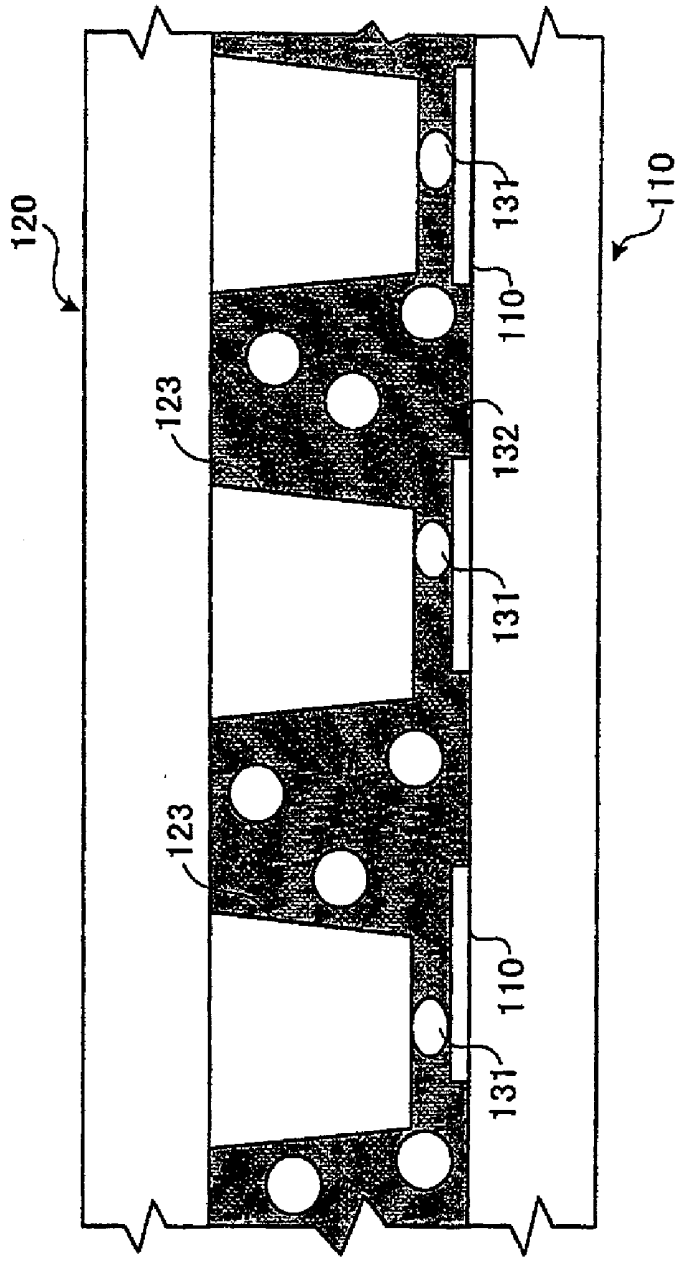
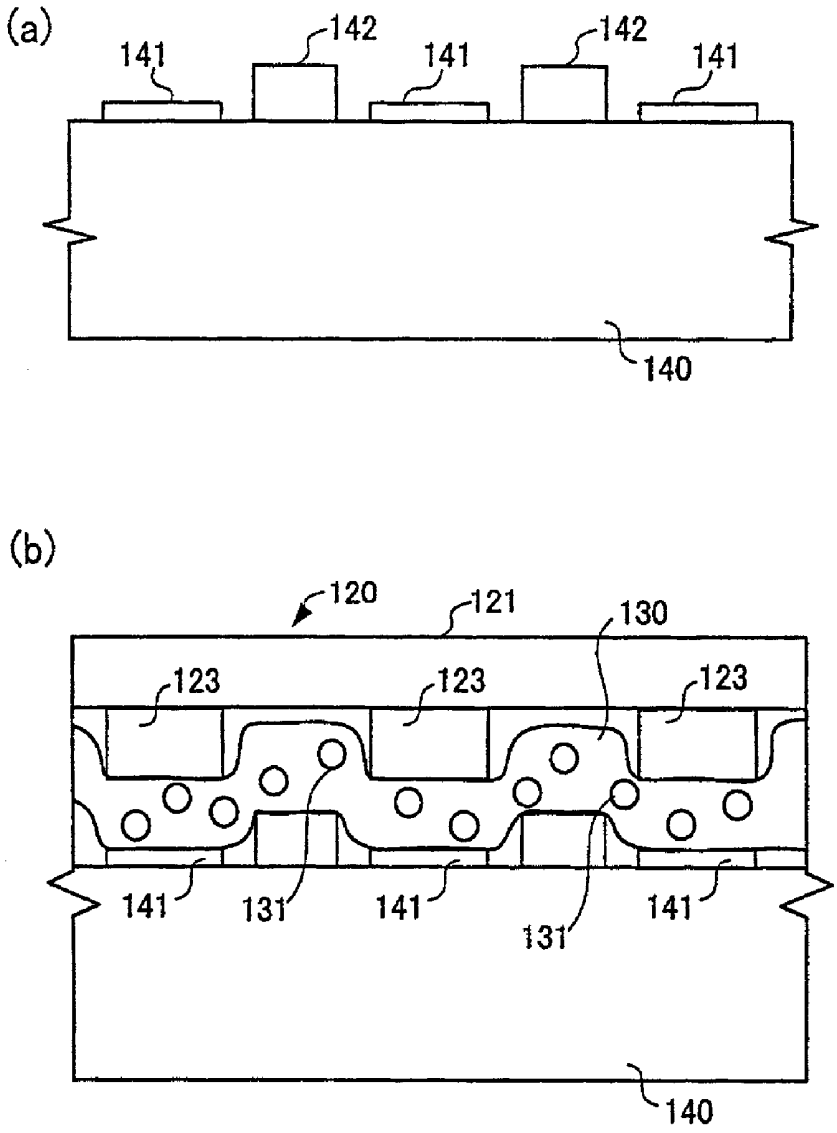


FIG. 11


(a)
141
142
141
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141
140
(b)
120
121
130
123
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123
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131
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131
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140

# LIQUID CRYSTAL DISPLAY DEVICE AND METHOD THEREOF

## BACKGROUND OF INVENTION

[0001] The present invention relates to a liquid crystal display device, more particularly, to a method of connecting drawing wires or pad wiring to array on a glass substrate, which constitutes the liquid crystal display panel, to a printed circuit board via a tape automated bonding (TAB) tape carrier package.

[0002] A liquid crystal display device has been remarkably widespread as an image display device for a personal computer or of other various types of monitors. The liquid crystal display device of this type typically constitutes a backlight as a plane-shaped light source for illumination is disposed on a back surface of the liquid crystal display panel. A liquid crystal plane having a specified area is illuminated to have even brightness as a whole, and thus an image formed on the liquid crystal plane is visualized.

[0003] The liquid crystal display device comprises: a liquid crystal display panel made from two glass substrates with a liquid crystal material being sealed therebetween. A printed circuit board for driving the liquid crystal material is mounted on the liquid crystal display panel. A backlight unit is disposed on the back surface of the liquid crystal display panel with a liquid crystal display panel holding frame being interposed therebetween. An outer frame surrounds the above-described components.

[0004] Among such liquid crystal display devices, in the case of a thin film transistor (TFT) liquid crystal display device, with respect to the two glass substrates making up the liquid crystal display panel, one glass substrate comprises an array substrate, and the other glass substrate comprises a color filter substrate. On the array substrate, drawing wires for electrically connecting the array substrate to the printed circuit board are formed, as well as TFTs as driving elements of the liquid crystal material, displaying electrodes and signal lines. Moreover, the TFTs are regularly arrayed on the glass substrate, thus referred to as the array substrate. On the color filter substrate, common electrodes, a black matrix and the like are formed besides color filters.

[0005] The printed circuit board is connected to the electrodes formed on the array substrate via a TAB tape carrier package. **FIG. 8** is a plan view showing an arrangement where a printed circuit board **100** and an array substrate **110** are connected to each other via a TAB tape carrier package **120**.

[0006] The TAB tape carrier package **120** includes: an insulating film tape **121**; input lead conductors **122** provided on the first surface of the insulating film tape **121**; and output lead conductors **123** provided on the second surface thereof. Moreover, the TAB tape carrier package **120** includes a chip attachment aperture **124** giving an attaching position of a liquid crystal driver chip **126**. The input lead conductors **122** extend from the chip attachment aperture **124** toward one edge of the TAB tape carrier package **120**. And, the input lead conductors **122** are terminated across a slender slot **125** formed along this one edge. The output lead conductors **123** extend from the chip attachment aperture **124** toward the other end of the TAB tape carrier package **120**. The liquid crystal driver chip **126** is connected to the input lead conductors **122** and the output lead conductors **123** at the position of the chip attachment aperture **124**.

[0007] The input lead conductors **122** of the TAB tape carrier package **120** are connected to corresponding conductors (not shown) of the printed circuit board **100** with solder, for example. Meanwhile, the output lead conductors **123** of the TAB tape carrier package **120** are connected to corresponding drawing wires on the array substrate **110**.

[0008] An anisotropic conductive film (ACF) has been used for connecting the output lead conductors **123** of the TAB tape carrier package **120** to the corresponding drawing wires on the array substrate **10**. The ACF is a film having conductive particles dispersed in a connecting member and having a thickness of 15 to 30 micrometers. A connecting method of the output lead conductors **123** of the TAB tape carrier package **120** to the corresponding electrodes of the array substrate **110** by the use of the ACF will be explained thereinafter, with reference to **FIGS. 9 and 10**.

[0009] **FIGS. 9 and 10** schematically show a cross-section of **FIG. 8** taken along a portion A-A. **FIG. 9** shows a situation before the TAB tape carrier package **120** and the array substrate **110** are connected to each other, and **FIG. 10** shows a situation after they are connected. In **FIG. 9**, the TAB tape carrier package **120** and the array substrate **110** face each other, and the output lead conductors **123** formed on a lower surface of the insulating film tape **121** and the drawing wires **111** formed on the array substrate **110** face each other. In this situation, the TAB tape carrier package **120** and the array substrate **110** are spaced apart with a specified gap to each other, and an ACF **130** is disposed therebetween. The ACF **130** as a connecting member typically has conductive particles **131** dispersed in thermosetting resin **132**. In a state where the output lead conductors **123** and the drawing wires **111** are aligned to each other, the TAB tape carrier package **120** and the array substrate **110** are compressed to be bonded to each other, and at the same time, the ACF **130** is heated. Then, the thermosetting resin **132** is softened, and then cured. As described above, the thermosetting resin **132** is softened and fluidized, and thus, as shown in **FIG. 10**, while the thermosetting resin **132** fills the gap between the TAB tape carrier package **120** and the array substrate **110**, the conductive particles **131** remaining between the output lead conductors **123** and the drawing wires **111** realize electrical connection between the output lead conductors **123** and the drawing wires **111**. This electrical connection brings about electrical connection between the array substrate **110** and the printed circuit board **100**.

[0010] Resolution of the liquid crystal display device has been-enhanced progressively, and in accordance with the enhancement of the resolution, a mutual pitch between the drawing wires **111**(and also output lead conductors **123**) has been narrowed. This narrowed pitch causes the following two technical subjects to the connection between the TAB tape carrier package **120** and the array substrate **110**, which is performed by the use of the ACF **130**.

[0011] The first technical subject is mis-positioning of the output lead conductors **123** to the drawing wires **111** due to thermal expansion of the TAB tape carrier package **120**. When the TAB tape carrier package **120** and the array substrate **110** are connected to each other by the use of the ACF **130**, the ACF **130** is heated. However, since only the ACF **130** cannot be locally heated, a periphery thereof is

also heated simultaneously. In this case, the insulating film tape **121** constituting the TAB tape carrier package **120** is thermally expanded to a larger extent as compared with the array substrate **110**. Accordingly, even if the drawing wires **111** and the output lead conductors **123** are aligned to each other before a heating step, mis-positioning between the drawing wires **111** and the output lead conductors **123** occurs after the heating step is performed therefore as shown in **FIG. 10**. In an extreme case, positions of the drawing wires **111** and the output lead conductors **123**, which correspond to each other, are completely misaligned, thus the reliability of the electrical connection cannot be secured. Therefore, it has been examined to dispose the output lead conductors **123**, estimating a thermal expansion coefficient of the insulating film tape **121**. However, under the situation where the resolution of the liquid crystal display device is further enhanced, the countermeasure examined as described above has reached the limit.

[**0012**] The second technical subject is that, in a process of connecting the TAB tape carrier package **120** and the array substrate **110** to each other, more specifically, in a thermocompression bonding process of the ACF **130**, the number of conductive particles **131** flowing out with the thermosetting resin from a space between the drawing wires **111** and the output lead conductors **123** is increased. In such a case, it becomes difficult to sufficiently secure the reliability of the electrical connection between the drawing wires **111** and the output lead conductors **123**.

[**0013**] A method capable of solving the above-described two technical subjects is disclosed in the gazettes of Japanese Patent Laid-Open Nos. Hei 4(1992)-132640 and Hei 11(1999)-186684. Specifically, in this method, protrusions **142** made of an insulative substance are formed between drawing wires **141** on a glass substrate **140** as shown in FIGS. **11**(*a*) and **11**(*b*). Thus, even if the insulating film tape **121** constituting the TAB tape carrier package **120** is expanded by heating, motion of the output lead conductors **123** is restricted by the protrusions **142**. Accordingly, there is no concern about the mis-positioning between the drawing wires **141** and the output lead conductors **123** after the heating step is performed therefore. Moreover, the flowing out of the conductive particles **131** in the ACF **130** from the space between the drawing wires **141** and the output lead conductors **123** can be prevented. Accordingly, the reliability of the electrical connection can be secured.

[**0014**] However, it has not been taught yet that the method proposed in the gazettes of Japanese Patent Laid-Open Nos. Hei 4(1992)-132640 and Hei 11(1999)-186684 is actually adopted for the liquid crystal display device. One factor for not adopting the method is that the method is not desirable from a viewpoint of a manufacturing cost of the liquid crystal display device, which is as important as higher resolution, since a new step must be added to the conventional manufacturing process of the liquid crystal display device in order to form the protrusions **142**.

## SUMMARY OF INVENTION

[**0015**] Accordingly, the object of the present invention is to provide a technique capable of securing the reliability of the electrical connection for the high-resolution liquid crystal display device without any additional step.

[**0016**] Specifically, a feature of the present invention provides a liquid crystal display panel having an array substrate having a driving element for a liquid crystal material formed thereon, a color filter substrate disposed facing to the array substrate with a specified gap therebetween, and a liquid crystal layer located in the gap between the array substrate and the color filter substrate. The array substrate includes an insulating substrate having an image displaying area and a non-image displaying area, the driving element for the liquid crystal material formed on the image displaying area on the insulating substrate, a polymer layer for covering the image displaying area including the driving element, a displaying electrode formed on the polymer layer and connected with the driving element electrically through the polymer layer, a plurality of drawing wires formed on the non-image displaying area of the insulating substrate for connecting to an exterior electrically, and a protrusion provided between the drawing wires adjacent to each other and made of resin of the same material as that of the polymer layer.

[**0017**] Another feature of the present invention provides a method for manufacturing a liquid crystal display panel. The method includes the steps of: (a) forming a driving element for a liquid crystal material and a plurality of drawing wires for electrically connecting to an exterior on an insulating substrate; (b) forming a polymer layer on the insulating substrate including the driving element and the drawing wires; (c) forming a through hole reaching the driving element in the polymer layer and removing the polymer layer existing on the drawing wires; and (d) forming a displaying electrode penetrating the through hole formed in the step (c) to be electrically connected to the driving element.

[**0018**] According to yet another feature of the present invention, provided is a liquid crystal display device in which a displaying electrode formed on an insulating layer and an array substrate including a plurality of drawing wires for electrically connecting to an exterior is provided, the liquid crystal display device comprising: a liquid crystal display panel including, an array substrate having a protrusion made of the same material as that of the insulating layer provided between the drawing wires adjacent to each other, a color filter substrate disposed facing to the array substrate, and a liquid crystal layer disposed between the array substrate and the color filter substrate, the liquid crystal layer consisting of a liquid crystal material; a circuit board for supplying a driving voltage to the liquid crystal material; and a sheet member for electrically connecting the circuit board and the liquid crystal display panel to each other, the sheet member having output conductors corresponding to the drawing wires.

[**0019**] Moreover, another feature of the present invention provides a liquid crystal display device having a liquid crystal display panel including a displaying electrode for applying a voltage to a liquid crystal material and a glass substrate having a plurality of drawing wires formed thereon for electrically connecting between the displaying electrode and an exterior, a circuit board for supplying the voltage to the liquid crystal material, and a sheet member for electrically connecting the glass substrate and the circuit board to each other. The sheet member is connected to the glass substrate with a connecting member. The glass substrate of the liquid crystal display panel has the displaying electrode provided on a polymer layer formed in an image displaying area of the liquid crystal display panel. Also, a dam being

made of the same material as that of the polymer layer is placed between the drawing wires adjacent to each other outside of the image displaying area.

[0020] The above-described liquid crystal display device of the present invention can be obtained by the following method. Specifically, the method of manufacturing a liquid crystal display device of the present invention is a method of manufacturing a liquid crystal display device, in which a liquid crystal display panel and a circuit board for driving the liquid crystal display panel are connected to each other via a tape carrier package, the liquid crystal display panel including a first insulating layer forming a displaying electrode on the surface thereof and a plurality of drawing wires performing electrical connection to an exterior, the method comprising the steps of: forming the first insulating layer and forming a second insulating layer between the drawing wires adjacent to each other in a process of obtaining the liquid crystal display panel; and connecting the tape carrier package and the liquid crystal display panel via a connecting member.

[0021] The present invention can be summarized as a connected body of substrates comprising: a first substrate including a plurality of first wires formed with a specified space therebetween, a first polymer layer formed between the first wires adjacent to each other, the first polymer layer having a thickness larger than the first wire, and a second polymer layer covering an area different from an area having the first wire and the first polymer layer formed thereon, the second polymer layer being formed of the same material as that of the first polymer layer; a second substrate including a plurality of second wires electrically connected to the first wires; and a connecting member layer mechanically connecting the first substrate and the second substrate.

[0022] Various other objects, features, and attendant advantages of the present invention will become more fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the several views.

## BRIEF DESCRIPTION OF DRAWINGS

[0023] For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings.

[0024] **FIG. 1** is a perspective view showing a liquid crystal display panel according to the embodiment of the subject invention.

[0025] **FIG. 2** is a cross-sectional view showing a liquid crystal display device according to the embodiment of the subject invention.

[0026] FIGS. **3**(*a*) to **3**(*c*) are views showing a manufacturing process of an array substrate according to the embodiment of the subject invention.

[0027] FIGS. **4**(*a*) to **4**(*c*) are views showing the manufacturing process of the array substrate according to the embodiment of the subject invention.

[0028] **FIG. 5** is a perspective view showing a peripheral area of the array substrate according to the embodiment of the subject invention.

[0029] **FIG. 6** is a view showing a step according to this embodiment, of connecting the array substrate and a TAB tape carrier package by the use of an ACF.

[0030] **FIG. 7** is a view showing a step according to this embodiment, of connecting the array substrate and the TAB tape carrier package by the use of the ACF.

[0031] **FIG. 8** is a plan view showing a connection of the array substrate and a printed circuit board by the TAB tape carrier package.

[0032] **FIG. 9** is a view showing a conventional step of connecting the array substrate and the TAB tape carrier package to each other by the use of the ACF.

[0033] **FIG. 10** is a view showing a conventional step of connecting the array substrate and the TAB tape carrier package to each other by the use of the ACF.

[0034] FIGS. **11**(*a*) and **11**(*b*) are views showing the conventional step of connecting the array substrate and the TAB tape carrier package to each other by the use of the ACF.

## DETAILED DESCRIPTION

[0035] Recently, a liquid crystal display panel (device) referred to as a "polymer film on array (PFA)" type has been developed. The PFA is a technique developed for the purpose of improving an aperture ratio. In the conventional TFT liquid crystal display device, a gap between displaying electrodes and signal lines in a horizontal direction must be secured to have a specified value or wider in order to prevent a short circuit therebetween. Since this gap becomes a portion where light irradiated from the light source of the liquid crystal display device leaks, a black matrix must cover this gap.

[0036] The improvement of the aperture ratio has been inhibited by the area covered with the black matrix in the conventional liquid crystal display device. Meanwhile, in the PFA-type liquid crystal display panel, a polymer layer as an insulating layer is formed, and the displaying electrodes are formed thereon. Thus, the gap between the displaying electrodes and the signal lines in the horizontal direction does not need to be secured.

[0037] Here, the PFA-type liquid crystal display device forms the polymer layer as the insulating layer. This polymer layer is required for an image displaying area of the liquid crystal display panel. Accordingly, though the polymer layer is once formed on a non-image displaying area, it has been removed afterward. The present invention was aimed at a method that a part of the polymer layer formed on the non-image displaying area, which has been heretofore removed, specifically, the polymer between the above-described drawing wires, is made to remain and function as the above-described protrusions. In this case, a step of providing a polymer layer for forming the protrusions does not need to be newly provided. And according to the method as described above, the protrusions made of the polymer of the same material as that of the polymer layer formed for the other purpose can be formed.

[0038] According to the liquid crystal display panel of the present invention, since the displaying electrode is provided on the polymer layer formed on the insulating substrate, a problem of a short circuit between the displaying electrode

and the signal line is solved. Moreover, according to the liquid crystal display panel of the present invention, since the protrusion provided between the drawing wires adjacent to each other is constituted of the same material as that of the polymer layer, the protrusion and the polymer layer can be formed in the same step. Accordingly, it is possible to enjoy a function as a protrusion, that is, an effect of preventing mis-positioning of the output lead conductors to the drawing wires, which is for securing the reliability of the electrical connection without any additional step.

[0039] As described above, in the liquid crystal display panel of the present invention, the protrusion can be formed in the same step of forming the polymer layer. In this case, the protrusion has substantially the same thickness as that of the polymer layer. Namely, a thickness of the protrusion can be set to 5 micrometers or less.

[0040] According to the method for manufacturing a liquid crystal display panel of the present invention, the polymer layer is formed on the insulating substrate once, and thereafter, the polymer layer on a specified area is removed by the same step. Thus, the through hole reaching the driving element is formed in the polymer layer, and the polymer layer existing on the drawing wires can be removed. In this case, though the polymer layer existing on the drawing wires is removed, the polymer layer between the drawing wires remains, and this remnant polymer layer forms the protrusion.

[0041] The liquid crystal display device of the present invention is a so-called PFA-type liquid crystal display device in which the displaying electrode is formed on the insulating layer. Accordingly, the problem of the short circuit between the displaying electrode and the signal line is solved. Moreover, in the liquid crystal display device of the present invention, since the protrusion provided between the drawing wires adjacent to each other is constituted of the same material as that of the insulating layer, the protrusion and the insulating layer can be formed in the same step. Accordingly, it is possible to enjoy a function as a protrusion, that is, an effect of preventing the mis-positioning of the output lead conductors to the drawing wires, which is for securing the reliability of the electrical connection without increasing the manufacturing cost.

[0042] In the liquid crystal display device of the present invention, conductive particles connecting the drawing wires and the output conductors, which are interposed between the drawing wires and the output conductors, can be provided. In this case, by the protrusion, the reliability of the electrical connection can be secured.

[0043] In order to sufficiently fulfill the function as a protrusion, in particular, the reliability of the electrical connection in the liquid crystal display device of the present invention, it is desirable that a thickness of the protrusion be set equal to a radius of each of the conductive particles or thicker. Moreover, the present invention can fulfill the function of preventing mis-positioning of the output lead conductors to the drawing wires and the function of securing the reliability of the electrical connection even in the high-resolution liquid crystal display device in which an interval between the drawing wires is 80 micrometers or less, further, 50 micrometers or less.

[0044] In the liquid crystal display device of the present invention, the sheet member can have a plurality of output conductors electrically connected to the drawing wires, and the connecting member can contain conductive particles electrically connecting the drawing wires and the output conductors to each other. In this case, the sheet member can include the plurality of output conductors electrically connected to the drawing wires, a tip portion of the dam can be disposed between the output conductors, in the event of a connecting process by the connecting member, the dam can prevent the conductive particles existing in the connecting member between the drawing wires and the output conductors from flowing out of a space between the drawing wires and the output conductors, and can prevent mis-positioning of the output conductors to the drawing wires due to thermal expansion of the sheet member.

[0045] Moreover, in the liquid crystal display device of the present invention, where a thickness of each of the output conductors is h**2**, and a radius of each of the conductive particles is d, it is desirable that a thickness hi of the dam be represented as: h1>h2+d for preventing from flowing out of the conductive particles.

[0046] Hereinbelow, description will be made for an embodiment of the present invention with reference to the drawings.

[0047] **FIG. 1** is a perspective view showing a state where driving circuit portions **51** and **52** are mounted on a liquid crystal display panel **20** of a liquid crystal display device **10** according to this embodiment.

[0048] The liquid crystal display panel **20** is constructed in such a manner that an array substrate **30** as a first glass substrate and a color filter substrate **40** as a second glass substrate having a smaller surface area than the array substrate **30** are superposed. The array substrate **30** and the color filter substrate **40** are disposed so as to face each other with a specified gap interposed therebetween. And in the gap, the liquid crystal material is sealed. As described below in detail, various elements for driving the liquid crystal material are formed on the surfaces of the array substrate **30** and the color filter substrate **40**, which face the gap. Along two sides of the array substrate **30**, the driving circuit areas **51** and **52** for driving the liquid crystal material are formed.

[0049] Since an area of the array substrate **30** excluding the driving circuit areas **51** and **52** is nearly equal to an area of the color filter substrate **40**, the driving circuit areas **51** and **52** are exposed to the outside when the array substrate **30** and the color filter substrate **40** are superposed. In these driving circuit areas **51** and **52**, the printed circuit board is connected via the TAB tape carrier package to the liquid crystal display panel **20**. Moreover, in the array substrate **30** and the color filter substrate **40**, the region surrounded by a two-dot dashed line represents an image displaying area **60**.

[0050] **FIG. 2** shows a cross-section of the liquid crystal display device **10** according to this embodiment.

[0051] As shown in **FIG. 2**, when listed from the above in the drawing, the liquid crystal display device **10** comprises: the liquid crystal display panel **20** including a polarizing plate **41**, the color filter substrate **40**, a liquid crystal layer **42** filled with the liquid crystal material, the array substrate **30** having a TFT **31** formed on a glass substrate as an insulating substrate, a polymer layer **32** formed on the array substrate **30**, and a displaying electrode **33** formed on the polymer layer **32** and conductively connected to the TFT **31** through

the polymer layer **32**; and a backlight unit **70** including a light guide plate **71** and a light source **72**. This liquid crystal display device **10** is a PFA-type liquid crystal display device having the displaying electrode **33** on the polymer layer **32**.

[**0052**] The construction of the TFT **31** is as follows. On the upper surface of the array substrate **30**, a gate insulating film **314** is deposited. In this gate insulating film **314**, a gate electrode **311** is formed, and on the gate insulating film **314**, a semiconductor film **315** is deposited. On the semiconductor film **315** as a thin film transistor, source and drain electrodes **312** and **313** are formed. Between the source and drain electrodes **312** and **313**, an etching protection film **316** is deposited. On the source and drain electrodes **312** and **313**, a protection film **317** is deposited.

[**0053**] When a voltage is applied to the gate electrode **311**, in a direction from the source electrode **312** to the drain electrode **313** or in a reverse direction, electrons pass through the semiconductor film **315** and thus current flows. When an OFF-state voltage is applied to the gate electrode **311**, the source electrode **312** and the drain electrode **313** are cut off. Specifically, the gate electrode **311** has a function of turning on and off the TFT **31** as a switching element. In this case, a voltage is applied from the drain electrode **313** to the displaying electrode **33**, and thus an electric field is generated between the displaying electrode **33** and a common electrode (not shown) formed on the color filter substrate **40**. The liquid crystal material in the liquid crystal layer **42** is driven in response to this electric field.

[**0054**] Here, the gate electrode **311** and the source and drain electrodes **312** and **313** consist of a metal film such as Al, Ta, MoTa, MoW or the like. Moreover, the displaying electrode **33** consists of a transparent indium tin oxide (ITO) film.

[**0055**] On a peripheral area of the array substrate **30** as the non-image displaying area, on which the driving circuit areas **51** and **52** are disposed, drawing wire **34** is formed to be electrically connected to the printed circuit board via the TAB tape carrier package. The drawing wire **34** in this embodiment has a three-layer structure as described later. The drawing wire **34** and the printed circuit board are connected to each other as described with reference to **FIG. 8**. Moreover, on the peripheral area of the array substrate **30**, a dam **35** is formed adjacently to the drawing wire **34**. This dam **35** is made of the same polymer material as that of the polymer layer **32**. The liquid crystal display device **10** according to this embodiment is characterized in that the dam **35** as a protrusion thicker than this drawing wire **34** is disposed adjacently to the drawing wire **34**. It should be noted that, although only the single drawing wire **34** and the single dam **35** are shown in **FIG. 2** for the sake of space convenience, the dam **35** is actually formed for each drawing wire **34** adjacent thereto.

[**0056**] Next, description will be made for a manufacturing process of the array substrate **30** according to this embodiment with reference to FIGS. **3**(*a*) to **3**(*c*) and **4**(*a*) to **4**(*c*).

[**0057**] First, on the array substrate **30**, a metal film for constituting the gate electrode **311** and the drawing wire **34** is deposited. Photo engraving process (PEP) is used to form the gate electrode **311** and the drawing wire **34**. Specifically, on a glass substrate constituting the array substrate **30**, the metal film constituting the gate electrode **311** and the drawing wire **34** is deposited by, for example, sputtering, and thereafter, the metal film is patterned by PEP as shown in **FIG. 3**(*a*). As the gate electrode **311**, as described above, the metal film such as Ta, MoTa, MoW, Al or the like can be used.

[**0058**] Note that, other conductive materials are stacked on the drawing wire **34** later, thus constituting the drawing wire **34**.

[**0059**] After forming the gate electrode **311** and the drawing wire **34**, a film for constituting the gate insulating film **314** is deposited. As the gate insulating film **314**, a silicon oxide (SiOx) film deposited by chemical vapour deposition (CVD) is typically used. A film for constituting the semiconductor film **315** is deposited on the film for constituting the gate insulating film **314** by CVD, for example. As the semiconductor film **315**, an amorphous silicon (a-Si) film can be used. A film for constituting the etching protection film **316** is deposited on the film for constituting the semiconductor film **315** by CVD, for example. As the etching protection film **316**, a silicon nitride (SiNx) film can be used. After depositing the film for constituting the etching protection film **316**, patterning is performed by PEP as shown in **FIG. 3**(*b*) to deposit the gate insulating film **314**, the semiconductor film **315** and the etching protection film **316**.

[**0060**] Next, a metal film for forming the source and drain electrodes **312** and **313** is deposited by sputtering, for example. For this metal film, Ta, MoTa, MoW, Al or the like can be used. After depositing this metal film, patterning is performed by PEP as shown in **FIG. 3**(*c*) to form the source and drain electrodes **312** and **313**. In this process, the metal film deposited on the drawing wire **34** is made to remain, and thus drawing wire **342** is formed.

[**0061**] Next, a film for constituting the protection film **317** for protecting the elements formed as before is deposited by CVD, for example, and thereafter, patterning is performed by PEP as shown in **FIG. 4**(*a*) to deposit the protection film **317**. As the protection film **317**, a silicon nitride (SiNx) film can be used.

[**0062**] Next, as shown in **FIG. 4**(*b*), the polymer layer **32** having a connection hole **32***b* penetrating to the drain electrode **313** is formed. This polymer layer **32** can be formed through the steps of coating a polymer solution, heating, curing and patterning by PEP. As the polymer constituting the polymer layer **32**, for example, acrylic resin, epoxy resin and polyvinyl alcohol can be used. Moreover, a thickness of the polymer layer **32** is set to be 5 micrometers or less, preferably, 1 to 5 micrometers. The polymer layer **32** is an essential element for this liquid crystal display device **10** to constitute the PFA-type liquid crystal display device. However, this embodiment is characterized in that the polymer layer **32** is formed also between the drawing wires **34**. Specifically, while the polymer layer **32** in the vicinity of the drawing wires **34** is removed by PEP performed after forming the polymer layer **32** in the conventional PFA-type liquid crystal display device, the polymer layer **32** between the drawing wires **34** is made to remain in this embodiment as found in **FIG. 4**(*b*).

[**0063**] Next, the ITO film for constituting the displaying electrode **33** is deposited on the polymer layer **32** by sputtering. After depositing the ITO film, patterning is performed by PEP as shown in **FIG. 4**(*c*) to form the

displaying electrode **33**. In this case, the ITO film deposited on the drawing wire **342** is made to remain. The remnant ITO film serves as drawing wire **343**, and constitutes the drawing wire **34** together with the layers for drawing wires **341** and **342**.

[**0064**] Thereafter, the color filter substrate **40** separately prepared is adhered onto the array substrate **30** via spacers and sealant (both are not shown). Thereafter, the liquid crystal material is filled into the gap between the array substrate **30** and the color filter substrate **40** to form the liquid crystal layer **42**. After filling the liquid crystal material, the polarizing plate **41** is attached onto the color filter substrate **40**. The liquid crystal display device **10** according to this embodiment shown in **FIG. 2** can be obtained by disposing the liquid crystal display panel **20** completed as before over the backlight unit **70**.

[**0065**] The liquid crystal display device **10** according to this embodiment is the PFA-type liquid crystal display device. Specifically, the displaying electrode **33** is formed on the polymer layer **32**. Accordingly, as seen head-on, the gap between the displaying electrode **33** and the signal line does not have to be provided, thus enabling the aperture ratio of the liquid crystal display device **10** to be improved.

[**0066**] Moreover, the liquid crystal display device **10** according to this embodiment allows the polymer layer **32** to remain between the drawing wires **34**. This polymer layer **32** having remained in a convex shape constitutes the dam **35**. **FIG. 5** is a partial perspective view showing the peripheral area of the array substrate **30**, particularly showing the peripheral area for connecting the liquid crystal display device **10** to the printed circuit board. The conventional connection mode shown in **FIG. 8** can be applied as it is to the connection in this embodiment of the liquid crystal display device **10** and the printed circuit board. Specifically, the drawing wires **34** are electrically connected to the output lead conductors **123** of the TAB tape carrier package **120** for connecting the liquid crystal display device **10** to the printed circuit board. As shown in **FIG. 5**, the dams **35** are disposed between these drawing wires **34**. As described with reference to **FIGS. 3 and 4**, these dams **35** are formed at the same time when the polymer layer **32** for constituting the PFA-type liquid crystal display device is formed. That is, there is an advantage that the dams **35** can be formed without any additional step.

[**0067**] Description will be made for a connecting method of the liquid crystal display device **10** and the TAB tape carrier package **120** with reference to **FIGS. 6 and 7**. **FIG. 6** shows a situation before the TAB tape carrier package **120** and the array substrate **30** are connected to each other, and **FIG. 7** shows a situation after they are connected to each other. In **FIG. 6**, the TAB tape carrier package **120** and the array substrate **30** are made to face each other, and the output lead conductors **123** formed on the lower surface of the insulating film tape **121** and the drawing wires **34** formed on the array substrate **30** are made to face each other. In this case, the TAB tape carrier package **120** and the array substrate **30** are spaced with each other with a specified gap, and the ACF **130** is disposed therebetween. The ACF **130** is typically formed in such a manner that the conductive particles **131** are dispersed in the thermosetting resin **132** as a connecting member. As the conductive particles **131**, fine powder of metal such as Ni and the one obtained by depositing a metal thin film surrounding fine powder made of resin can be used. In a state where the output lead conductors **123** and the drawing wires **34** are aligned to each other, the TAB tape carrier package **120** and the array substrate **30** are compressed and bonded to each other, and simultaneously, the ACF **130** is heated. Then, the thermosetting resin **132** is softened, and thereafter, is cured. The thermosetting resin **132** is softened and fluidized, and thus, as shown in **FIG. 7**, while the thermosetting resin **132** fills the gap between the TAB tape carrier package **120** and the array substrate **30**, the conductive particles **131** remaining between the output lead conductors **123** and the drawing wires **34** realize the electrical connection between the output lead conductors **123** and the drawing wires **34**.

[**0068**] According to this embodiment, the following effects are achieved by the dams **35** provided between the drawing wires.

[**0069**] Firstly, the mis-positioning of the output lead conductors **123** to the drawing wires **34** due to thermal expansion of the TAB tape carrier package **120** can be suppressed. Specifically, even if the insulating film tape **121** constituting the TAB tape carrier package **120** is expanded by heating during the thermo-compression bonding of the ACF **130**, the mis-positioning between the drawing wires **34** and the output lead conductors **123** can be minimized after the thermo-compression bonding since the motion of the output lead conductors **123** is restricted due to the presence of the dams **35**. At least, the mis-positioning leading to the difficulty in the electrical connection between the drawing wires **34** and the output lead conductors **123**, which correspond to each other, is not caused. Secondly, escape of the conductive particles **131** from the space between the output lead conductors **123** and the drawing wires **34** can be suppressed. Specifically, in the process of connecting the TAB tape carrier package **120** to the array substrate **30**, particularly during the thermo-compression bonding of the ACF **130**, the thermosetting resin **132** is softened and fluidized to be flowed out from the space between the output lead conductors **123** and the drawing wires **34**. In this case, some of the conductive particles **131** are flowed out from the space between the output lead conductors **123** and the drawing wires **34**. In the conventional array substrate **110** shown in **FIGS. 9 and 10**, there is nothing between the drawing wires **111**, and thus the conductive particles **131** are easily flown out. On the contrary to this, in the liquid crystal display device **10** according to this embodiment, the dams **35** are formed between the drawing wires **34**, and these dams **35** enter spaces between the output lead conductors **123**. Thus, the flowing out of the conductive particles **131** from the space between the output lead conductors **123** and the drawing wires **34** can be suppressed.

[**0070**] As described above, the dams **35** play an important role for achieving two effects: one is the prevention of the mis-positioning of the output lead conductors **123** to the drawing wires **34**; and the other is the prevention of the flowing out of the conductive particles **131**. And, the liquid crystal display device **10** according to this embodiment is most characterized in that the PFA-type liquid crystal display device having the effects as described above can be manufactured without any additional step. Specifically, these two effects, which are the prevention of the mis-positioning of the output lead conductors **123** to the drawing wires **34** and the prevention of the flowing out of the

conductive particles **131**, are achieved without any additional step, while enjoying the benefit of the PFA-type liquid crystal display device capable of increasing the aperture ratio, thus leading to an advantage for the high resolution of the liquid crystal display device **10**.

[**0071**] The dams **35** according to this embodiment are desirably provided with the following conditions in order to obtain the above-described effects. Firstly, with regard to the dimension, the minimum condition is that each of the dams **35** is thicker than the drawing wire **34**. If the dams **35** is thinner than the drawing wire **34**, it is difficult to obtain the two effects which are the prevention of the mis-positioning of the output lead conductors **123** to the drawing wires **34** and the prevention of the flowing out of the conductive particles **131**. Moreover, with regard to the relation between the dams **35** and the conductive particles **131** in size, each of the dams **35** desirably has a thickness equal to a radius of the conductive particle **131** or more. If the dam **35** is thinner relative to the conductive particle **131**, there is an increased possibility that the conductive particle **131** runs up onto the dam **35** in the process of thermo-compression bonding of the ACF **130**, and thus it may be incapability of sufficiently enjoying the restriction effects for the escape of the conductive particles **131**. Furthermore, with regard to the relation of the dams **35** with the output lead conductors **123** and the conductive particles **131**, the following condition is desirable. Specifically, where the thickness of each of the output lead conductors **123** is h2, and the radius of each of the conductive particles **131** is d, the thickness hi of each of the dams **35** is represented as: h1>h2+d in order to enjoy the effects by the dams **35** sufficiently. However, it is not desirable that the thickness of the dam **35** be made larger than necessary. The thickness should be set to 5 micrometers or less, desirably 1 to 5 micrometers. The thickness of the dam **35** has been described as above. The width of each of the dams **35** depends almost on the pitch of the drawing wires **34**. The pitch of the drawing wires **34** depends on the resolution of the liquid crystal display device **10**. Specifically, the higher the resolution of the liquid crystal display device **10** is, the more the number of the drawing wires **34** is increased. In accordance with the increase in number, the width and pitch of the drawing wires **34** are narrowed. Recently, the pitch of the drawing wires **34** has been extremely minimized to 80 micrometers or less, or further, to some 50 micrometers or less. In this case, the width of the dam **35** is set to be a value below 80 micrometers, or even below 50 micrometers.

[**0072**] Here, according to the examination of the inventor, with regard to the distribution of the conductive particles **131** during the connection by the use of the ACF **130**, the followings have been found out under the conditions where the pressure and temperature during the connection are fixed. It should be noted that a capture ratio mentioned herein is referred to as a ratio of the conductive particles **131** remaining in the space between the drawing wires **34** and the output lead conductors **123** after they are heated and cured to the number of the conductive particles **131** to be present between the drawing wires **34** and the lead conductors **123** on the assumption that the conductive particles **131** do not flow out.

[**0073**] The distribution of the conductive particles **131** has a correlation with the density thereof in the ACF **130** for use in the connection.

[**0074**] The distribution takes a generally binomial distribution in any particle diameter.

[**0075**] When the area of the drawing wire **34** is reduced, that is, when the pitch is shortened, the capture ratio of the conductive particles **131** does not take a linear proportional relation.

[**0076**] Based on viscosity of resin as a binder constituting the ACF **130**, both the capture ratio and the distribution are changed.

[**0077**] The size of the conductive particles **131** has little to do with the reliability of the electrical connection and the size of the total connection area of the captured conductive particles **131** affects the reliability of the electrical connection.

[**0078**] The inventor actually measured the capture ratio. When the pitch of the drawing wires **34** was 120 micrometers, the capture ratio was 40%. When the pitch was 75 micrometers, it was 30%. And when the pitch was 64 micrometers, it was 13%. The capture ratio is reduced as described above. As the pitch is narrowed, the capture ratio does not show a linear proportion but a nearly quadratic curve to the pitch. However, the present inventor confirmed that, by providing the dams **35** as in this embodiment, the capture ratio of the same level as in the case where the pitch was about 120 micrometers could be secured even in the case where the pitch was narrowed to 80 micrometers, or further, to some 50 micrometers. Therefore, according to this embodiment, it is suggested to be possible to secure the electrical connection between the drawing wires **34** and the output lead conductors **123** of the TAB tape carrier package **120** even in the liquid crystal display device **10** where the pitch is narrowed, in other words, even in the liquid crystal display device **10** having the enhanced resolution. Moreover, the reliability of the electrical connection can be enhanced by obtaining the capture ratio proportional to the density of the conductive particles **131** of the ACF **130** even if the pitch of the drawing wires **34** is changed.

[**0079**] The following effects can be also achieved by forming the dams **35** in the same process as that for the polymer layer **32**. Specifically, according to this embodiment, since the polymer layer **32** exists to the peripheral area of the array substrate **30**, the evenness inside the surface of the cell gap, which is formed when the color filter substrate **40** is superposed onto the array substrate **30**, is improved, in comparison with the conventional liquid crystal display panel in which the polymer layer **32** in the peripheral area has been removed. This results in contribution to the improvement of image quality. Moreover, when the polymer layer **32** is patterned, the polymer layer **32** subject to etching exists evenly in the image displaying area and peripheral area of the array substrate **30**. Therefore, a difference in the etching rate, which depends on the area, is lowered. Accordingly, it shows an effect that the incidence of pattern defects represented by side etching is lowered.

[**0080**] The liquid crystal display device **10** described above is an embodiment of the present invention, and does not constitute a base for limiting the present invention. For example, the present invention can be also applied to a known back channel etch-type TFT or a top gate-type TFT as a structure of the TFT. Moreover, although the ACF **130** including the conductive particles **131** is used, the electrical

connection between the drawing wires **34** and the output lead conductors **123** can be also obtained by directly contacting the both. Specifically, resin which does not include the conductive particles **131** can be used as a connecting member. In this case, the reliability of the electrical connection between the output lead conductors **123** and the drawing wires **34** can be secured by the effect of preventing mis-positioning of the output lead conductors **123** to the drawing wires **34**, the effect being brought about by the dams **35**. Furthermore, with regard to the materials constituting the respective constituent components including the gate electrode **311**, the source and drain electrodes **312** and **313** and the like, other materials than the ones exemplified above can be used.

[**0081**] And, with regard to the process of manufacturing the array substrate **30**, other processes more simplified than the one shown in **FIG. 3** can be also adopted.

[**0082**] As described above, according to the present invention, the mis-positioning between the drawing wires and the output lead conductors can be effectively prevented, and the reliability of the electrical connection of the both can be secured.

[**0083**] Moreover, in the case where the ACF is used for the connection, the capture ratio of the conductive particles is increased, and the reliability of the electrical connection thereof can be secured.

[**0084**] In the above, description has been made on the assumption that the present invention will be applied to the liquid crystal display device. However, an application object of the present invention is not limited to the liquid crystal display device, and the present invention can be widely applied to the purpose of jointing the wires to each other via the conductive particles.

[**0085**] Although the preferred embodiment of the present invention has been described in detail, it should be understood that various changes, substitutions and alternations can be made therein without departing from spirit and scope of the inventions as defined by the appended claims.

**1**. A liquid crystal display panel comprising:

an array substrate having a driving element for a liquid crystal material formed thereon;

a color filter substrate disposed facing to said array substrate with a specified gap therebetween; and

a liquid crystal layer located in the gap between said array substrate and said color filter substrate,

wherein said array substrate includes:

an insulating substrate having an image displaying area and a non-image displaying area;

the driving element for the liquid crystal material formed on said image displaying area on said insulating substrate;

a polymer layer for covering said image displaying area including said driving element;

a displaying electrode formed on said polymer layer and electrically connected to said driving element through said polymer layer;

a plurality of drawing wires formed on said non-image displaying area of said insulating substrate for electrically connecting to an exterior; and

a protrusion provided between said drawing wires adjacent to each other, the protrusion made of the same material as that of said polymer layer.

**2**. The liquid crystal display panel according to claim 1, wherein said protrusion has substantially the same thickness as that of said polymer layer.

**3**. The liquid crystal display panel according to claim 1, wherein a thickness of said protrusion is 5 micrometers or less.

**4**. A method of manufacturing a liquid crystal display panel, said method comprising the steps of:

(a) forming a driving element for a liquid crystal material and a plurality of drawing wires for electrically connecting to an exterior on an insulating substrate;

(b) forming a polymer layer on said insulating substrate including said driving element and said drawing wires;

(c) forming a through hole reaching said driving element in said polymer layer and removing said polymer layer existing on said drawing wires; and

(d) forming a displaying electrode penetrating said through hole formed in said step (c) to be electrically connected to said driving element.

**5**. A liquid crystal display device in which a displaying electrode formed on an insulating layer and an array substrate including a plurality of drawing wires for electrically connecting to an exterior are provided, said liquid crystal display device comprising:

a liquid crystal display panel including an array substrate having a protrusion made of the same material as that of said insulating layer provided between said drawing wires adjacent to each other, a color filter substrate disposed facing to said array substrate, and a liquid crystal layer disposed between said array substrate and said color filter substrate, the liquid crystal layer consisting of a liquid crystal material;

a circuit board for supplying a driving voltage to said liquid crystal material; and

a sheet member for electrically connecting said circuit board and said liquid crystal display panel to each other, the sheet member having output conductors corresponding to said drawing wires.

**6**. The liquid crystal display device according to claim 5, further comprising conductive particles for electrically connecting said drawing wires and said output conductors to each other, the conductive particles being interposed between said drawing wires and said output conductors.

**7**. The liquid crystal display device according to claim 6, wherein said protrusion has a thickness equal to a radius of said conductive particles or larger.

**8**. The liquid crystal display device according to claim 6, wherein an interval between said drawing wires is 80 micrometers or less.

**9**. A liquid crystal display device comprising:

a liquid crystal display panel including a displaying electrode for applying a voltage to a liquid crystal material and a glass substrate having a plurality of drawing wires formed thereon for electrically connecting between said displaying electrode and an exterior;

a circuit board for supplying said voltage to the liquid crystal material; and

a sheet member for electrically connecting said glass substrate and said circuit board to each other, the sheet member being connected to said glass substrate with a connecting member,

wherein said glass substrate of said liquid crystal display panel has said displaying electrode provided on a polymer layer formed in an image displaying area and has a dam made of the same material as that of said polymer layer between said drawing wires adjacent to each other outside said image displaying area.

**10**. The liquid crystal display device according to claim 9, wherein said sheet member has a plurality of output conductors electrically connected to said drawing wires, and

said connecting member contains conductive particles electrically connecting

said drawing wires and said output conductors to each other.

**11**. The liquid crystal display device according to claim 10, wherein a tip portion of said dam is disposed between said output conductors, and

in the event of a connecting process by said connecting member, said dam prevents the conductive particles existing between said drawing wires and said output conductors in said connecting member from flowing out of a space between said drawing wires and said output conductors, and prevents mis-positioning of said output conductors to said drawing wires due to thermal expansion of said sheet member.

**12**. The liquid crystal display device according to claim 10,

wherein, where a thickness of said output conductors is h2, and a radius of said conductive particles is d, a thickness h1 of said dam is represented as: $h1>h2+d$.

**13**. A method of manufacturing a liquid crystal display device, in which a liquid crystal display panel and a circuit board for driving said liquid crystal display panel are connected to each other via a tape carrier package, the liquid crystal display panel including a first insulating layer forming a displaying electrode on a surface thereof and a plurality of drawing wires electrically connecting to an exterior, said method comprising the steps of:

forming said first insulating layer and forming a second insulating layer between said drawing wires adjacent to each other in a process of obtaining said liquid crystal display panel; and

connecting said tape carrier package and said liquid crystal display panel via a connecting member.

**14**. A connected body of substrates comprising:

a first substrate including a plurality of first wires formed with a specified space therebetween, a first polymer layer formed between said first wires adjacent to each other, the first polymer layer having a thickness larger than said first wire, and a second polymer layer covering an area different from an area having said first wire and said first polymer layer formed thereon, the second polymer layer being formed of the same material as that of said first polymer layer;

a second substrate including a plurality of second wires electrically connected to said first wires; and

a connecting member layer mechanically connecting said first substrate and said second substrate.

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摘要(译)

在彼此相邻的拉丝之间形成挡板。该阻挡层是在阵列（PFA）型液晶显示装置上的聚合物膜中形成其上具有显示电极的聚合物层的相同步骤中形成的。