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DISPLAY ELEMENT AND MANUFACTURING METHOD FOR SAME

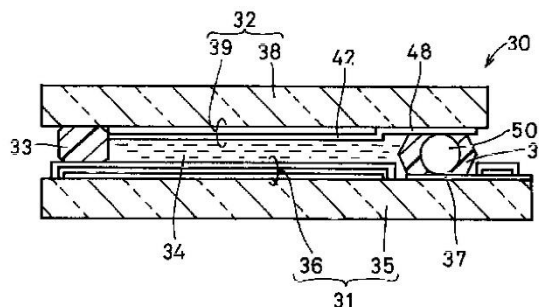
(57) Abstract

Problem

To provide a display element in which a non-display region can be made small and reliable conduction between two electrode substrates can be achieved.

Solution

Electrode substrates 31, 32 are bonded together by a sealing material 33, in a state in which a common electrode 37 and a connection electrode 48 oppose each other, to obtain conduction between the electrode substrates. The sealing material 33 is provided at a location at which it is partially sandwiched between the common electrode 37 and the connection electrode 48, and a conductive material 50 having conductivity is mixed into the sealing material 33 only in the portions that are sandwiched between the common electrode 37 and the connection electrode 48. In this manner, the region in which the sealing material 33 is disposed and the region in which the common electrode 37, the connection electrode 48, and the conductive material 50 are disposed can be shared, a non-display region 53 can be made small, and the conductive material 50 can be reliably brought into contact with the common electrode 37 and the connection electrode 48 to achieve reliable conduction between the electrode substrates 31, 32.



CLAIMS

1. A display element comprising:

two opposingly disposed electrode substrates, wherein inter-substrate conducting-electrode portions for creating conduction between the electrode substrates are respectively formed at opposing locations;

a bonding material that is provided at a location at which it is partially sandwiched between the inter-substrate conducting-electrode portions and that bonds the electrode substrates together; and

a conductive material that has conductivity and is mixed only into the portion of the bonding material that is sandwiched between the inter-substrate conducting-electrode portions.

2. The display element according to claim 1, wherein the conductive material is conductive particles in which metal layers are formed on the surfaces of base particles composed of synthetic resin.

3. A display-element manufacturing method comprising:

a bonding material disposition step in which a bonding material, which is for bonding together two electrode substrates on which are formed inter-substrate conducting-electrode portions for creating conduction between the electrode substrates, is provided in a region including on the inter-substrate conducting-electrode portion of one of the two electrode substrates; and

a conductive material disposition step in which a holding material, which is diluted with a volatile material and composed of a material similar to the bonding material and into which a conductive material is mixed, is provided in a region on the inter-substrate conducting-electrode portion of any one of the two electrode substrates.

4. A display-element manufacturing method comprising:

a bonding material disposition step in which a bonding material, which is for bonding together two electrode substrates on which are formed inter-substrate conducting-electrode portions for creating conduction between the electrode substrates, is provided in a region including on the inter-substrate conducting-electrode portion of one of the two electrode substrates; and

a conductive material disposition step in which a holding material, which is composed of a volatile material and into which a conductive material is mixed, is provided in a region over the inter-substrate conducting-electrode portion of any one electrode substrate of the two electrode substrates.

DETAILED DESCRIPTION OF THE INVENTION

[0001]

TECHNICAL FIELD PERTAINING TO THE INVENTION

The present invention relates to a display element, such as a liquid-crystal display element, and a manufacturing method for the same.

[0002]

RELATED ART

FIG. 7 is a cross-sectional view showing a portion of a conventional liquid-crystal display element 1. FIG. 8 is a cross-sectional view showing the entire liquid-crystal display element 1. FIG. 9 is a cross-sectional view as seen along a cross-sectional line S9-S9 in FIG. 8. The liquid-crystal display element 1 is an active-matrix-type display element comprising an array substrate 2 and a color-filter substrate 3. An electrode is formed on each of the substrates 2, 3, the substrates 2, 3 are bonded together by a sealing material 4 composed of an epoxy-based resin with the surface portions on which the electrodes are formed opposing each other, and a liquid-crystal material 15 is sealed within a space surrounded by the sealing material 4 between the substrates 2, 3 to form the liquid-crystal display element 1.

[0003]

In the liquid-crystal display element 1, to simplify connection with a driver for driving the liquid-crystal display element

1, all of a plurality of terminals 5, 6 for connecting with the driver are provided on the array substrate 2 and configured to be connectable to the driver all together. To describe in detail, the plurality of array substrate terminals 5 for electrically connecting a pixel electrode 7 formed on the array substrate 2 to the driver, and the plurality of color-filter substrate terminals 6 for electrically connecting a counter electrode 8 formed on the color-filter substrate 3 to the driver, are formed on the array substrate 2.

[0004]

When the color-filter substrate terminals 6 are provided on the array substrate 2 in this manner, there must be conduction between the color-filter substrate terminals 6 and the electrode formed on the color-filter substrate 3. For this reason, a common electrode 9 electrically connected to the color-filter substrate terminals 6 is formed on the array substrate 2, a connection electrode 10 electrically connected to the counter electrode 8 is formed on the color-filter substrate 3 at a location opposing the common electrode 9, and a conductive paste 11 containing fine conductive powders, such as carbon powder, silver powder, and nickel powder in a thermosetting phenolic resin, is provided between the common electrode 9 and the connection electrode 10. In the liquid-crystal display element 1, the sealing material 4 is provided in a ring shape in a ring-shaped non-display region 13 surrounding a display region 12 in which the pixel electrode 7 is provided, and the common electrode 9, the connection electrode 10, and the conductive paste 11 are disposed at locations offset inward from the sealing material 4.

[0005]

FIG. 10 is a cross-sectional view showing another conventional liquid-crystal display element 1A as a whole. The liquid-crystal display device 1A is analogous to the liquid-crystal display element 1 in FIG. 6 to FIG. 8, and only elements differing therefrom will be described; similarly configured portions will be labeled with the same reference numerals, and descriptions thereof will be omitted. The liquid-crystal display element 1A shown in FIG. 9 is disclosed in Unexamined Japanese Patent Application Publication No. 2001-142084. In the liquid-crystal display device 1A, a sealing material 4A into which are mixed fine conductive particles is provided so as to overlap the common electrode 9.

[0006]

PROBLEMS TO BE SOLVED BY THE INVENTION

The non-display region 13 outside the display region 12 is not only a connection region necessary to connect the terminals 5, 6 and the driver using tape-automated bonding (TAB), but is also necessary for a sealing material disposition region in which the sealing material 4 is disposed and a conductive paste disposition region in which the conductive paste 11 is disposed, and a width dimension L13 of the non-display region 13 adversely becomes large if the connection region, the sealing material disposition region, and the conductive paste disposition region are provided separately. In the liquid-crystal display element 1 shown in FIG. 6 to FIG. 8, the sealing material 4 and the conductive paste 11 are different types of curable materials, and the conductive paste 11 is disposed inside the sealing material 4 so as not to overlap the sealing material 4. The conductive paste 11 need only not overlap the sealing material 4, and may be disposed outside the sealing material 4; either way, the sealing material 4 and the conductive paste 11 must be disposed at separate locations in the inward-outward direction; therefore, the

width dimension L13 of the non-display region 13 becomes adversely large.

[0007]

If the width dimension L13 of the non-display region 13 becomes adversely large in this manner, it will constrain the design of a display panel configured using the liquid-crystal display element 1, forcing a design in which the so-called "bezel" becomes large relative to the size of the display screen. To put it in opposite terms, the display region in the pattern design of the array substrate 2 adversely becomes small relative to the overall dimensions of the display panel. Moreover, the bezel of a display device naturally adversely becomes large when the display device is manufactured using the display panel.

[0008]

The conductive paste 11 used in the liquid-crystal display element 1 is configured to have conductivity through point contact among the plurality of fine conductive powders in the paste, and, in addition to having high electrical resistance, increases in electrical resistance as the cell gap increases.

[0009]

FIG. 11 is an enlarged cross-sectional view showing the vicinity of the common electrode 9 of the liquid-crystal display element 1A. In FIG. 11, a surface portion of the color-filter substrate 3 is shown on the upper side, and a surface portion of the array substrate 2 is shown on the lower side. The liquid-crystal display element 1A of Unexamined Japanese Patent Application Publication No. 2001-142084 shown in FIG. 9 is capable of solving the above-mentioned problems of the liquid-crystal display element 1 in FIG. 7 to FIG. 9, but has two new problems.

[0010]

Structurally, the array substrate 2 has a step height $\Delta H9$ between the surface of the common electrode 9 and the surface of a layered film 17 formed adjacent to the common electrode 9. A first insulating film of the array substrate electrode 5 is formed around the periphery of the common electrode 9 via plasma chemical vapor deposition (CVD) using silicon nitride (SiN_x) and silicon oxide (SiO_2) or the like, a source-line electrode is laid in another layer formed via sputtering using tantalum (Ta) or the like, and a second insulating film is laid in another layer formed in the same manner as the first insulating film. In some instances, a resin film may be overcoated as a planarizing film, and the step height $\Delta H9$ between the surface of the layered film 17 and the surface of the common electrode 9 may be 3 μm or more.

[0011]

The particle outer diameter D19 of conductive particles 19 dispersed in the sealing material 4A is set to dimensions that are optimal when disposed between the common electrode 9 and the connection electrode 10; however, because the conductive particles 19 are uniformly dispersed in the sealing material 14, they are also adversely present in the regions facing the layered film 17, a spacing L9 between the common electrode 9 and the connection electrode 10 is greater than the particle outer diameter D19, and the conductive particles 19 present between the common electrode 9 and the connection electrode 10 are covered by the resin material of the sealing material 4, adversely causing poor conduction between the common electrode 9 and the connection electrode 10. This is the first problem.

[0012]

In addition, because the sealing material 4A into which the conductive particles 17 are uniformly mixed is provided in a state surrounding the display region 12, an insulating layer must be formed in order to prevent the conductive particles 19 from adversely creating undesirable conduction between, for example, a connection line extending from the electrode disposed within the display region 12 to the array substrate electrode 5 and other electrodes, wires, etc. This is the second problem. Moreover, providing this insulating layer exacerbates the first problem.

[0013]

An object of the present invention is to provide a display element in which the non-display region can be made small and reliable conduction between the two electrode substrates can be achieved.

[0014]

MEANS FOR SOLVING THE PROBLEMS

The present invention is a display element that comprises: two opposingly disposed electrode substrates, wherein inter-substrate conducting-electrode portions for creating conduction between the electrode substrates are respectively formed at opposing locations; a bonding material that is provided at a location at which it is partially sandwiched between the inter-substrate conducting-electrode portions and that bonds the electrode substrates together; and a conductive material that has conductivity and is mixed only into the portion of the bonding material that is sandwiched between the inter-substrate conducting-electrode portions.

[0015]

According to the present invention, the two electrode substrates are bonded together by a bonding material in a state in which inter-substrate conducting-electrode portions for creating conduction between the electrode substrates oppose each other. The bonding material is provided at a location at which it is partially sandwiched between the inter-substrate conducting-electrode portions, and a conductive material having conductivity is mixed into the bonding material. In this manner, the region in which the bonding material is disposed and the region in which the inter-substrate conducting-electrode portions and the conductive material are disposed can be made to partially coincide and be shared. The non-display region in which the bonding material, the inter-substrate conducting-electrode portions, and the conductive material are disposed can thereby be made small.

[0016]

In addition, the conductive material is not mixed into the entirety of the bonding material, but mixed only into the portion of the bonding material that is sandwiched between the inter-substrate conducting-electrode portions. Accordingly, even if the layer configuration of the electrode substrates differs between the portions in which the inter-substrate conducting electrodes are formed and the remaining portions, the conductive material in the remaining portions is prevented from becoming a spacer and adversely setting the spacing between the inter-substrate conducting-electrode portions to greater than the design dimensions, the conductive material is reliably brought into contact with the inter-substrate conducting electrode portions, and the inter-substrate conducting electrode portions can be reliably electrically connected. In this manner, it is possible to make the non-display region small and achieve reliable conduction between the electrode substrates.

[0017]

In the present invention, the conductive material is conductive particles in which metal layers are formed on the surfaces of base particles composed of synthetic resin.

[0018]

According to the present invention, the conductive material is conductive particles composed of metal layers formed on the surfaces of base particles composed of synthetic resin; thus, the conductive particles can be deformed by applying pressure. Accordingly, it is possible to set the dimensions of the conductive particles to greater than the design dimensions between the inter-substrate conducting-electrode portions, deform the conductive particles by applying pressure when the electrode substrates are bonded together, tolerate dimensional errors in the electrode substrates, and reliably create conduction between the inter-substrate

conducting-electrode. In addition, by applying pressure to deform the conductive particles in the state in which they are sandwiched between the electrode substrates, it is possible to reliably bring the inter-substrate conducting-electrode portions and the conductive particles into surface contact, which also makes it possible to achieve reliable conduction between the inter-substrate conducting-electrode portions.

[0019]

In addition, the present invention is a display element manufacturing method comprising: a bonding material disposition step in which a bonding material for bonding together two electrode substrates on which are formed inter-substrate conducting-electrode portions for creating conduction between the electrode substrates is provided in a region including on the inter-substrate conducting-electrode portion of one of the two electrode substrates; and a conductive material disposition step in which a holding material that is diluted with a volatile material and composed of a material similar to the bonding material, and into which a conductive material is mixed, is provided in a region over the inter-substrate conducting-electrode portion of either one of the two electrode substrates.

[0020]

According to the present invention, the bonding material is provided in a region including on the inter-substrate conducting-electrode portion of either one of the electrode substrates. In addition, a holding material that is diluted with a volatile material and composed of a material similar to the bonding material, and into which a conductive material is mixed, is provided in a region over the inter-substrate conducting-electrode portion of either one of the electrode substrates. The bonding material and the holding material may be provided on the same electrode substrate, or may be provided on different electrode substrates. A display element can be manufactured by disposing such electrode substrates so that the inter-substrate conducting-electrode portions oppose each other, and bonding them together with the bonding material.

[0021]

By providing the holding material into which the conductive material is mixed, the electrode substrates can be bonded together in a state in which the conductive material is reliably held over the inter-substrate conducting-electrode portions of the electrode substrates. The display element thus manufactured is provided with a bonding material at a location at which the material is partially sandwiched between the inter-substrate conducting-electrode portions, and the conductive material is mixed only into the portion of this bonding material that is sandwiched between the inter-substrate conducting-electrode portions.

[0022]

The holding material is composed of a material similar to the bonding material and diluted with a volatile material; thus, if the volatile material vaporizes, the holding material can function similarly to the bonding material, and the bonding together of the electrode substrates by the bonding material is not affected. Moreover, the amount of the holding material after the vaporization of the volatile material can be made smaller, the dimensions of the bonding material between the inter-substrate conducting-electrode portions into which the conductive material is mixed can be kept small, and the non-display region can be kept small. In this manner, it is possible to easily manufacture a display element in which it is possible to make the non-display region small and achieve reliable conduction between the electrode substrates.

[0023]

In addition, the present invention is a display element manufacturing method comprising: a bonding material disposition step in which a bonding material for bonding together two electrode substrates, on which are formed inter-substrate conducting-electrode portions for creating conduction between the electrode substrates, is provided in a region including on the inter-substrate conducting-electrode portion of one electrode substrate of the two electrode substrates; and a conductive material disposition step in which a holding material that is composed of a material having volatility and into which a conductive material is mixed, is provided in a region over the inter-substrate conducting-electrode portion of either electrode substrate of the two electrode substrates.

[0024]

According to the present invention, the bonding material is provided in a region including on the inter-substrate conducting-electrode portion of either one of the electrode substrates. In addition, a holding material that is composed of a material having volatility and into which is mixed a conductive material is provided in a region over the inter-substrate conducting-electrode portion of either one of the electrode substrates. The bonding material and the holding material may be provided on the same electrode substrate, or may be provided on different electrode substrates. A display element can be manufactured by disposing such electrode substrates so that the inter-substrate conducting-electrode portions oppose each other, and bonding them together with the bonding material.

[0025]

By providing the holding material into which the conductive material is mixed, the electrode substrates can be bonded together in a state in which the conductive material is reliably held over the inter-substrate conducting-electrode portions of the electrode substrates. The display element thus manufactured is provided with a bonding material at a location at which the material is partially sandwiched between the inter-substrate conducting-electrode portions, and the conductive material is mixed only into the portion of this bonding material that is sandwiched between the inter-substrate conducting-electrode portions.

[0026]

The holding material is composed of a material having volatility; thus, if the volatile material vaporizes, only the conductive material ends up remaining, and the bonding together of the electrode substrates by the bonding material is not affected. Moreover, the amount of the holding material after the vaporization of the volatile material can be made small, the dimensions of the bonding material between the inter-substrate conducting-electrode portions into which the conductive material is mixed can be kept small, and the non-display region can be kept small. In this manner, a display element can be easily manufactured in which the non-display region can be made small and reliable conduction between the electrode substrates can be achieved.

[0027]

MODES FOR CARRYING OUT THE INVENTION

FIG. 1 is a cross-sectional view showing a portion of a display element 30 according to one embodiment of the present invention. FIG. 2 is a cross-sectional view showing the display element 30 as a whole. FIG. 3 is a cross-sectional view as seen along a cross-sectional line S2-S2 in FIG. 2. In the present embodiment, the display element 30 is a liquid-crystal display element, wherein two electrode substrates 31, 32 are disposed and layered spaced apart from each other in an opposing state and are bonded together by a sealing material 33 provided in a rectangular closed-loop shape, and a liquid-crystal material 34 is sealed in the space surrounded by the sealing material 33 between the electrode substrates 31, 32 to form the display element 30.

[0028]

The first electrode substrate 31 is an array substrate constituted by a laminate 36 formed from a plurality of films formed and layered on the surface of one thickness-direction side of a glass substrate 35. The laminate 34 of the first electrode substrate 31 comprises a gate-line electrode constituting a scan electrode, a common electrode 37, a gate-insulating film, a semiconductor film, a source-line electrode constituting a signal electrode, and a drain electrode; and further comprises a transparent pixel electrode 49, composed of indium-tin oxide (abbreviated ITO) or the like, for each display pixel arranged in a matrix shape, and a liquid-crystal alignment layer composed of a polyimide or the like.

[0029]

The second electrode substrate 31 is a color-filter substrate constituted by a laminate 39 formed by a plurality of films formed and layered on the surface of one thickness-direction side of a glass substrate 38. The laminate 39 of the second electrode substrate 31 comprises a filter provided with three primary color layers, red (R), green (G) and blue (B), and a black mask (abbreviated BM) for each display pixel, comprises a planarization-process layer for performing a planarization process thereupon, and further comprises, over all

pixels, a transparent counter electrode 42 composed of ITO or the like and a liquid-crystal alignment layer composed of a polyimide or the like.

[0030]

The surface portions of the electrode substrates 31, 32 on which are formed the laminates 36, 39 are made to oppose each other, the cell gap, which is the spacing between the alignment layers in a display region 52 in which the transparent pixel electrode 49 is disposed, is made uniform, and the glass substrates 35, 36 are bonded together by the sealing material 33 while in a state of being held at a predetermined spacing using spacers to make the thickness of the liquid-crystal layer in the display region 52 uniform. The sealing material 33 is disposed and provided surrounding the entire perimeter of a display region 40 in which the transparent pixel electrode 49 formed on the first electrode substrate 31 is disposed. The spacers comprise in-plane spacers provided in the display region 52 in which the transparent pixel electrode 49 is disposed, and peripheral spacers mixed into the sealing material 33.

[0031]

The display element 30 is electrically connected to a driver integrated circuit (abbreviated IC) and is driven to display by the driver IC. Specifically, a drive voltage is selectively applied between each transparent pixel electrode 49 and the transparent counter electrode by the driver IC, and the alignment state of the liquid-crystal material 34 is selected for each display pixel.

[0032]

In order to selectively apply the voltage between each transparent pixel electrode 49 and the transparent counter electrode, a thin-film transistor (TFT) serving as a switching element is provided for each transparent pixel electrode 49 on the first electrode substrate 31. The driver IC applies a constant potential to the transparent counter electrodes, and controls the TFTs to apply a selectively differing potential to the corresponding transparent pixel electrodes 49. In this manner, for each display pixel, the voltage between the transparent pixel electrode 49 and the transparent counter electrode is selected and the alignment state of the liquid-crystal material 34 is selected, and an image is displayed.

[0033]

A terminal group 43 for electrically connecting with the driver IC is formed in the display element 30, and terminals of a terminal group formed in the driver IC via tape-automated bonding (TAB) are electrically connected to terminals 44, 45 of the terminal group 43. In this manner, the display element 30 and the driver IC are electrically connected. The terminal group 43 of the display element 30 comprises the plurality of one-substrate terminals 44 for electrically connecting the electrode formed on the first electrode substrate 31 and the driver IC, and the plurality of other-substrate terminals 45 for electrically connecting the electrode formed on the second electrode substrate 31 and the driver IC.

[0034]

More specifically stated, in the first electrode substrate 31,

the gate-line electrode, the source-line electrode, and the drain electrode are electrically connected to a gate region, a source region, and a drain region of the TFT, respectively, and the drain electrode is electrically connected to each of the transparent pixel electrodes 49. The one-substrate terminals 44 are electrically connected to the gate-line electrodes and the source-line electrodes via connection lines, and a different potential can be applied to each of the transparent pixel electrodes 49 by the driver IC. In contrast, in the second electrode substrate 31, a constant potential need only be applied to the transparent counter electrode, and the other-substrate terminals 45 are electrically connected to the transparent counter electrode.

[0035]

In order to facilitate connection between the display element 30 and the driver IC, the terminals 44, 45 are all formed on the first electrode substrate 31 so that the terminals 44, 45 and the terminals of the driver IC can be electrically connected at once, i.e., in a single step. In other words, the other-substrate terminals 45 are also formed on the first electrode substrate 31. The first electrode substrate 31 is formed larger than and in a stacked state with the second electrode substrate 31, and the terminals 44, 45 are formed in the portions thereof protruding outward from the second electrode substrate 31.

[0036]

In this manner, the one-substrate terminals 44 comprise: a plurality of gate terminals disposed on a one-side edge of the glass substrate 35 of the first electrode substrate 31, formed by being routed from the gate-line electrode by connection lines, and disposed in a lined-up state in a direction along the one-side edge; and a plurality of source terminals disposed on an other-side edge adjacent to the one-side edge of the glass substrate 35 of the first electrode substrate 31, formed by being routed from the source-line electrode by connection lines, and disposed in a lined-up state in a direction along the other-side edge. In addition, the other-substrate terminals 45 are disposed on the other-side edge of the glass substrate 35 of the first electrode substrate 31, formed by being routed from the common electrode 37 by connection lines, and disposed, together with the source terminals of the one-substrate terminals 44, in a lined-up state in a direction along the other-side edge.

[0037]

When forming the other-substrate terminals 45 on the first electrode substrate 31, a conductive portion for creating conduction between the transparent counter electrode substrate and the other-substrate terminals must be provided spanning between the electrode substrates 31, 32 in order to electrically connect the other-substrate terminals 45 and the transparent counter electrode of the second electrode substrate 31. To this end, the common electrode 37, which is electrically connected to an other-substrate electrode 45 via a connection line, is formed on the first electrode substrate 31, a connection electrode 48, which is electrically connected to the transparent counter electrode 42, is formed on the second electrode substrate 31, and a conductive material 50 is provided between the common electrode 37 and the connection electrode 48. The transparent counter electrode 42 and the connection electrode 48 may be realized by a single electrode.

[0038]

In the display element 30, the display region 52, which is a region in which images are displayed and in which the transparent pixel electrode 49 is disposed, surrounds the entire perimeter to form a non-display region 53, in which images are not displayed. The sealing material 33, the terminal group 43 comprising the terminals

44, 45, the common electrode 37, the connection electrode 48, and the conductive material 50 are disposed in the non-display region 53.

[0039]

The common electrode 37 and the connection electrode 48, which are inter-substrate conducting-electrode portions for creating conduction between the electrode substrates 31, 32, oppose each other in a state in which the electrode substrates 31, 32 are stacked. The sealing material 33, which is a bonding material for bonding the electrode substrates 31, 32 together, is provided at a location partially sandwiched between the common electrode 37 and the connection electrode 48, i.e., in a ring-shaped region that includes a region portion that is sandwiched between the common electrode 37 and the connection electrode 48. The ring-shaped region is a portion of the non-display region 53.

[0040]

FIG. 4 is an enlarged cross-sectional view showing the vicinity of the common electrode 37 of the display element 30. The conductive material 50 constitutes conductive particles in which metal layers are formed on the surfaces of synthetic-resin base particles (plastic beads: PB). This conductive material 50 is mixed only into the portion of the sealing material 33 that is sandwiched between the common electrode 37 and the connection electrode 48.

[0041]

A thermosetting resin material and a photosetting-thermosetting synthetic resin material, for example, can be used as the sealing material 33. The thermosetting resin material is composed, for example, of a thermosetting resin such as an epoxy-based resin; and, for example, XS-21S (trade name) produced by Mitsui Chemicals, Inc., W/R780P-45F2 (trade name) produced by Kyoritsu Chemical & Co., Ltd., and ML3900P (trade name) produced by ThreeBond Co., Ltd., can be used as the sealing material 33 composed of a thermosetting resin. The photosetting-thermosetting resin material is, for example, a material in which a thermosetting resin such as an epoxy-based resin and a photosetting resin such as an acrylate are mixed; and, for example, D70-E1 and D70-E3 (both trade names) produced by Kyoritsu Chemical & Co., Ltd., and 30Y392D and 30Y-447 (both trade names) produced by ThreeBond Co., Ltd., can be used as the sealing material 33 composed of a photosetting-thermosetting resin material.

[0042]

For example, particles constituted by spherical synthetic-resin base particles metal-plated with gold (Au) or nickel (Ni)—specifically, for example, AU Spacers (trade name) produced by Sekisui Chemical Co., Ltd.—can be used as the conductive material 50.

[0043]

According to this display element 30, the sealing material 33 is provided at a location at which it is partially sandwiched between the common electrode 37 and the connection electrode 48, and the conductive material 50 having conductivity is mixed into the sealing material 33. In this manner, the region in which the sealing material 33 is disposed and the regions in which the common electrode 37, the connection electrode 48, and the conductive material 50 are disposed can be made to partially coincide and be shared. The non-display region 53 in which the sealing material 33, the common electrode 37, the connection electrode 48, and the conductive material 50 are disposed can thus be made small. In other words, the width dimension L53 of the non-display region 53 can be made small.

[0044]

Accordingly, in the display panel configured by connecting the driver IC to the display element 30, the dimensions of the bezel formed by covering the non-display region 53 outside the display region 52 of the display element 30 with a cover body or the like can be made small, and the bezel can thereby be made narrower.

Concurrently, the portion outside the display region 52 in the display device configured using the display panel can also be made small.

[0045]

In addition, the conductive material 50 is not mixed into the entirety of the sealing material 33, but is mixed only into the portion of the sealing material 33 that is sandwiched between the common electrode 37 and the connection electrode 48; thus, even if the layer configurations of the electrode substrates 31, 32 differ between the portions in which the common electrode 37 and the connection electrode 48 are formed and the remaining portion of the ring-shaped region in which the sealing material 33 is disposed, the undesirable establishment of a cell gap by the conductive material 50 in the remaining portion is prevented. Stated in greater detail, the layer configuration of the laminate 36 structurally differs between the portion in which the common electrode 37 is formed and the portions, other than this portion, in which the sealing material 33 is provided on the first electrode substrate 31, and the surface thereof has a step height $\Delta H37$.

[0046]

In the portion in which the common electrode 37 is formed, the laminate 36 is only the common electrode 37, whereas in the portions other than said portion in which the sealing material 33 is provided, to give the portion adjacent to the common electrode 37 as an example, a first insulating film, which covers connection lines connected to the one-substrate terminals 44, is formed via plasma chemical vapor deposition (CVD) using silicon nitride (SiNx), silicon oxide (SiO₂), or the like, the source-line electrode is laid in another layer formed by sputtering tantalum (Ta) or the like, and the second insulating film is laid in another layer formed in the same manner as the first insulating film. In some instances, a resin film overcoat is applied as a planarizing film. In this manner, the portion in which the sealing material 33 is provided, other than the portion in which the common electrode 37 is formed, has a complex layer configuration and large thickness, and the step height $\Delta H37$ of the surface may be, for example, 3 μm or more.

[0047]

In this state, the spacing L36 between the laminate 36 and the connection electrode 48 in the portion in which the sealing material 33 is provided, other than the portion in which the common electrode 37 is formed, is smaller than the spacing L37 between the common electrode 37 and the connection electrode 48. In view of this point, the conductive material 50 is mixed only into the portion between the common electrode 37 and the connection electrode 48 in the present invention. As a result, the conductive material 50 in the portion other than the portions of the common electrode 37 and the connection electrode 48 is prevented from adversely setting the spacing L37 between the common electrode 37 and the connection electrode 48 to be greater than the design dimensions, the conductive material 50 is reliably brought into contact with the common electrode 37 and the connection electrode 48, the conductive material 50 can be reliably electrically connected to the common electrode 37 and the connection electrode 48, and conduction can be reliably created between the common electrode 37 and the connection electrode 48 with low electrical resistance, and a display element 30 having high display quality and stability can be obtained. Reductions in display quality caused by the undesired establishment of a cell gap are also prevented.

[0048]

In addition, in the display element 30, the cell gap is set to predetermined design dimensions by the spacers. Dimensions

commensurate with the cell gap set by the spacers are selected for the conductive material 50. Specifically, the outer diameter D50 of the conductive material 50 is greater than the spacing L37 between the common electrode 37 and the connection electrode 48 in a state in which a cell gap is set, and is set, for example, to approximately 1.2 times ($D50 = 1.2 \times L37$). For example, if the spacing L37 between the common electrode 37 and the connection electrode 48 is 6.2 μm , 7.4 μm is selected for the outer diameter D50 of the conductive material 50.

[0049]

Because the conductive material 50 has base particles composed of synthetic resin, it can be deformed by applying pressure. By thus setting the cell gap using glass spacers, the plasticity of the base particles can be utilized to deform the conductive material 50 and bring it into surface contact with the common electrode 37 and the connection electrode 48. In this manner, reliable conduction between the common electrode 37 and the connection electrode 48 can be achieved, and dimensional errors such as manufacturing errors in the electrode substrates 31, 32 can be tolerated.

[0050]

FIG. 5 is a flow chart illustrating a manufacturing method for the display element 30. When manufacturing is initiated in step a0, first, the laminates 36, 39 are formed on the glass substrates 35, 38 to form the electrode substrates 31, 32 in step a1.

[0051]

After the formation of the electrode substrates 31, 32, in-plane spacers are provided on the first electrode substrate 31 in step a2. The in-plane spacers are of the thermal-reactive fixing type, are composed, for example, of a thermosetting synthetic resin that has translucence, and have dimensions, such as particle size, corresponding to the cell gap. The in-plane spacers are provided by being scattered over the display region 52.

[0052]

After the in-plane spacers have been provided, the in-plane spacers are fixed by thermally treating the first substrate 31 in step a3. In the thermal treatment of the first electrode substrate 31 for this fixing of the in-plane spacers, the first electrode substrate 31 is left for 10 minutes on a hotplate held at 120°C. The in-plane spacers are thereby thermally solidified and fixed.

[0053]

After the in-plane spacers have been fixed, the conductive material 50 is provided on the first electrode substrate 31 in step a4. The conductive material 50 is provided in a state in which it is mixed into the holding material and held by the holding material. The holding material is composed of a material similar to the sealing material 33, and, accordingly, is a material composed, for example, of an epoxy-based resin that is a thermosetting resin and is diluted approximately 100-fold with a material having volatility. For example, toluene, ethyl acetate, tetrahydrofuran (THF), butyl carbitol, or the like can be used as the volatile material. The conductive material 50 is mixed into this holding material so that the mixture ratio of the conductive material 50 and the holding material is 1:500 by weight. The holding material into which the conductive material 50 is mixed is applied onto the common electrode 37, thereby providing the conductive material 50.

[0054]

The holding material into which the conductive material

50 is mixed is applied, for example, by using a pressure-discharge type dispenser, disposing a nozzle having a tip inner diameter of 0.2 mm so that the spacing between the common electrode 37 constituting the target of application and the nozzle tip is 0.2 mm, and discharging from the nozzle onto the common electrode 37, which has a surface area of approximately 1 mm², in a substantially cylindrical shape having a diameter of approximately 200 μm and a height of 30 μm . In this manner, 40 particles/mm², i.e., approximately 40 particles of the conductive material 50 in a square mm unit region, are held on the common electrode 37.

[0055]

After this holding material has been provided, the first substrate 31 is thermally treated to vaporize (dry) the volatile material in the holding material in step a5.

[0056]

In this thermal treatment, it is necessary to set a temperature to prevent ignition depending on the type of solvent; specifically, if tetrahydrofuran is used, it is volatilized by being held for 10 minutes on a hotplate held at 30°C.

[0057]

After the volatile material in the holding material has been vaporized, the sealing material 33 is provided on the second electrode substrate 32 in step a6. In a state in which the glass spacers are mixed therein, the sealing material 33 is applied to a region including on the connection electrode 48 of the second electrode substrate 32 so as to define the region.

[0058]

After the sealing material 33 has been provided, the second electrode substrate 32 is thermally treated to prebake the sealing material 33 in step a7. In the thermal treatment of the second electrode substrate 32 to pre-dry the sealing material 33, the second electrode substrate 32 is left for 60 minutes on a hotplate held at 90°C to pre-solidify the sealing material 33.

[0059]

After the in-plane spacers, the conductive material 50, and the sealing material 33 have been provided and temporarily fixed in this manner, the electrode substrates 31, 32 are bonded together in step a8. This bonding is performed, for example, by loading the electrode substrates 31, 32 into a vacuum chamber and evacuating the interior of the vacuum chamber, in which state a cell equivalent of liquid-crystal material is dispensed dropwise into the space surrounded by the sealing material 33 of the second electrode substrate 32, relatively positional adjustment of the electrode substrates 31, 32 is performed, and they are bonded together using the sealing material 33.

[0060]

After the electrode substrates 31, 32 have been bonded together in this manner, downstream processes, such as thermal treatment to effect final baking and solidification of the sealing material 33, are performed as appropriate to manufacture the display element 30, and the manufacturing process ends in step a9.

[0061]

In this manner, the manufacturing method shown in FIG. 5 includes: a bonding material disposition step in which the sealing material 33 for bonding together the two electrode substrates 31, 32, on which are formed the common electrode 37 and the connection electrode 48 constituting the inter-substrate conducting-electrode portions, is provided on one of the two substrates—in the present embodiment, a region including on the connection electrode 48 of the second electrode substrate 32; and a conductive material disposition step in which the holding material, which is diluted with a volatile material and composed of a material similar to the sealing material 33 and into which the conductive material 50 has been mixed, is provided on the other of the electrode substrates 31, 32—in the present embodiment, a region on the common electrode 37 of the first electrode substrate 31.

[0062]

According to this method, the electrode substrates can be bonded together in a state in which the conductive material 50 is reliably held on the common electrode 37 by applying the holding material into which the conductive material 50 is mixed. In this manner, it is possible to manufacture the display element 30 in which the sealing material 33 is provided at a location partially sandwiched between the common

electrode 37 and the connection electrode 48, and the conductive material 50 is mixed only with the portion of the sealing material 33 sandwiched between the common electrode 37 and the connection electrode 48. In other words, the display element 30, in which the non-display region 53 is made small and reliable conduction between the electrode substrates 31, 32 can be achieved, can easily be manufactured.

[0063]

By using, as the holding material, a holding material that is composed of a material similar to the sealing material 33 and that is diluted with a volatile material, the amount of the holding material relative to the conductive material 50 can be increased when applying the holding material to the common electrode 37, thereby facilitating the application work; and, after that application and before bonding the electrode substrates 31, 32 together, the amount of the holding material relative to the conductive material 50 can be reduced by performing a thermal treatment to vaporize the volatile material, which makes it possible to keep down the dimensions of the portions of the sealing material 33 into which the conductive material 50 is mixed, thus contributing to reducing the size of the display region 53.

[0064]

Moreover, despite the thermal treatment, only the volatile material vaporizes, rather than everything vaporizing, and a portion composed of a material similar to the sealing material 33 remains, making it possible to maintain the held state of the conductive material 50. Furthermore, the remaining portion is mixed with the sealing material 33 and functions similarly during bonding; thus, the bonding of the electrode substrates 31, 32 is not affected. In addition, by using the same material for the sealing material 33 and the holding material, the degree of deformation during bonding can be made consistent, enabling suitable bonding. In other words, bonding defects resulting from a lack of deformation on one side, as when a conductive paste of a material different from the sealing material is used as in the conventional art, do not occur.

[0065]

The method in FIG. 5 has been described with the scattering of the in-plane spacers, the fixing of the in-plane spacers, the application of the holding material, the vaporization of the volatile material, the application of the sealing material 33, and the pre-baking of the sealing material 33 being performed in this order; however, this is non-limiting, and, as long as the in-plane spacer fixing process is performed after the scattering thereof, the volatile material vaporization (drying) process is performed after the application of the holding material, and the pre-baking of the sealing material 33 is performed after the application of the sealing material 33, the order of the rest may be altered, as appropriate, and it is possible to similarly obtain the display element 30 and to achieve similar effects.

[0066]

In the method in FIG. 5, the holding material into which is mixed the conductive material 50 is applied on the common electrode 37 of the first electrode substrate 31, and the sealing material 33 is applied to a region including on the connection electrode 48 of the second electrode substrate 32; however, it is also acceptable to apply the holding material into which is mixed the conductive material 50 onto the connection electrode 48 of the second electrode substrate 32, and apply the sealing material 33 to a region including on the common electrode 37 of the first electrode substrate 31. In this instance, the in-plane spacers may be scattered over the second electrode substrate 32.

[0067]

FIG. 6 is a flow chart showing another manufacturing method for the display element 30. The manufacturing method in FIG. 6 is analogous to the manufacturing method in FIG. 5. When manufacturing is initiated in step b0, first, the electrode substrates 31, 32 are formed in step b1 in the same manner as in step a1 in FIG. 5. After the formation of the electrode substrates 31, 32, in-plane spacers are provided on the first electrode substrate 31 in step b2 in the same manner as in step a2 of FIG. 5.

[0068]

After the in-plane spacers have been provided, the conductive material 50 is provided on the first electrode

substrate 31 in step b3. The conductive material 50 is provided in a state in which it is mixed into the holding material and held by the holding material. In the method of FIG. 6, the holding material is composed of a volatile material. For example, toluene, ethyl acetate, tetrahydrofuran (THF), butyl carbitol, or the like can be used as the volatile material. The conductive material 50 is mixed into this holding material so that the mixture ratio of the conductive material 50 and the holding material is 2:1000 by weight. The holding material into which the conductive material 50 is mixed is applied onto the common electrode 37, thereby providing the conductive material 50.

[0069]

The holding material into which the conductive material 50 is mixed is applied, for example, by using a pressure-discharge type dispenser, disposing a nozzle having a tip inner diameter of 0.2 mm so that the spacing between the common electrode 37 constituting the target of application and the nozzle tip is 0.2 mm, and discharging from the nozzle onto the common electrode 37, which has a surface area of approximately 1 mm², in a substantially cylindrical shape having a diameter of approximately 300 μm and a height of 10 μm. In this manner, approximately 25 particles/mm², i.e., approximately 25 particles of the conductive material 50 in a square mm unit region, are held on the common electrode 37.

[0070]

After the in-plane spacers and the conductive material 50 have been provided held in the holding material, the first substrate 31 is thermally treated to fix the in-plane spacers and to vaporize the volatile material of the holding material in step b4. In this thermal treatment of the first electrode substrate 31, the first electrode substrate 31 is left for 10 minutes on a hotplate held at 120°C. In this manner, the fixing treatment of the in-plane spacers and the vaporization treatment of the volatile material of the holding material can be combined, and the number of steps can be reduced.

[0071]

After the in-plane spacers have been fixed and the volatile material in the holding material has been vaporized, the sealing material 33 is provided on the second electrode substrate 32 in step b5 in the same manner as in step a6 in FIG. 5. After the sealing material 33 has been provided, the sealing material 33 is pre-solidified in step b6 in the same manner as in step a7 in FIG. 5.

[0072]

After the in-plane spacers, the conductive material 50, and the sealing material 33 have been provided and temporarily fixed in this manner, the electrode substrates 31, 32 are bonded together in step b7 in the same manner as in step a8 in FIG. 5. After the electrode substrates 31, 32 have been bonded together in this manner, downstream processes, such as thermal treatment to effect final baking and solidification of the sealing material 33, are performed as appropriate to manufacture the display element 30, and the manufacturing process ends in step b8.

[0073]

In this manner, the manufacturing method shown in FIG. 6 includes: a bonding material disposition step in which the sealing

material 33 for bonding together the two electrode substrates 31, 32, on which are formed the common electrode 37 and the connection electrode 48 constituting the inter-substrate conducting-electrode portions, is provided on one of the two substrates—in the present embodiment, a region including on the connection electrode 48 of the second electrode substrate 32; and a conductive material disposition step in which the holding material, which is composed of a volatile material and into which the conductive material 50 has been mixed, is provided on the other of the electrode substrates 31, 32—in the present embodiment, a region on the common electrode 37 of the first electrode substrate 31.

[0074]

According to this method, the electrode substrates can be bonded together in a state in which the conductive material 50 is reliably held on the common electrode 37 by applying the holding material into which the conductive material 50 is mixed. In this manner, it is possible to manufacture the display element 30 in which the sealing material 33 is provided at a location partially sandwiched between the common electrode 37 and the connection electrode 48, and the conductive material 50 is mixed only with the portion of the sealing material 33 sandwiched between the common electrode 37 and the connection electrode 48. In other words, the display element 30, in which the non-display region 53 is made small and reliable conduction between the electrode substrates 31, 32 can be achieved, can easily be manufactured.

[0075]

By using, as the holding material, a holding material that is composed of a volatile material, the amount of the holding material relative to the conductive material 50 can be increased when applying the holding material to the common electrode 37, thereby facilitating the application work; and, after that application and before bonding the electrode substrates 31, 32 together, the amount of the holding material relative to the conductive material 50 can be reduced by performing a thermal treatment to vaporize the volatile material, which makes it possible to keep down the dimensions of the portions of the sealing material 33 into which the conductive material 50 is mixed, thus contributing to reducing the size of the display region 53.

[0076]

The conductive material 50 used in this instance is particles having a particle size of 8 μm or less, and the conductive material 50 does not adversely scatter as a result of the electrode substrate 31 being transported. This is because the volatilization of the holding material creates an electrostatically stable state between the electrode substrate 31 and the conductive material 50; thus, the force seeking to return to the stable state works against the force seeking to move.

[0077]

Moreover, because the holding material is vaporized and does not remain, it will not mix with the sealing material 33 during bonding and affect the bonding together of the electrode substrates 31, 32. In addition, the degree of deformation of the sealing material 33 during bonding can be made consistent, enabling suitable bonding. In other words, bonding defects resulting from a lack of deformation on one side, as when a conductive paste of a material different from the sealing material is used as in the conventional art, do not occur.

[0078]

The method in FIG. 6 has been described with the scattering of the in-plane spacers, the application of the holding material, the fixing of the in-plane spacers and the vaporization of the volatile material, the application of the sealing material 33, and the pre-baking of the sealing material 33 being performed in this order; however, this is non-limiting, and, as long as the in-plane spacer fixing process is performed after the scattering thereof, the volatile material vaporization (drying) process is performed after the application of the holding material, and the pre-baking of the sealing material 33 is performed after the application of the sealing material 33, the order of the rest may be altered, as appropriate, and it is possible to similarly obtain the display element 30 and to achieve similar effects.

[0079]

In the method in FIG. 6, the holding material into which is mixed the conductive material 50 is applied on the

common electrode 37 of the first electrode substrate 31, and the sealing material 33 is applied to a region including on the connection electrode 48 of the second electrode substrate 32; however, it is also acceptable to apply the holding material into which is mixed the conductive material 50 onto the connection electrode 48 of the second electrode substrate 32, and apply the sealing material 33 to a region including on the common electrode 37 of the first electrode substrate 31. In this instance, the in-plane spacers may be scattered over the second electrode substrate 32.

[0080]

In the methods in FIG. 5 and FIG. 6, the in-plane spacers and the holding material into which the conductive material 50 has been mixed are provided on the same electrode substrate, and the sealing material 33 is provided on another, different electrode substrate; however, this is non-limiting, and the holding material into which the conductive material 50 has been mixed and the sealing material 33 may be provided on the same electrode substrate. In this instance, the in-plane spacers may be provided on the same substrate as these, or may be provided on a different substrate, and either of the holding material in FIG. 5 and the holding material in FIG. 6 can be used as the holding material.

[0081]

Also, in instances wherein the holding material, into which the conductive material 50 is mixed, and the sealing material 33 are provided on the same electrode substrate, the order of the scattering of the in-plane spacers, the fixing of the in-plane spacers, the application of the holding material, the fixing of the in-plane spacers, the vaporization of the volatile material, the application of the sealing material 33, and the prebaking of the sealing material 33 is not otherwise limited as long as the in-plane spacer fixing process is performed after the scattering thereof, the volatile material vaporization (drying) process is performed after the application of the holding material, and the prebaking of the sealing material 33 is performed after the application of the sealing material 33. In addition, when providing the holding material, into which the conductive material 50 is mixed, and the sealing material 33 on the same electrode substrate, if the prebaking of the sealing material 33 is performed after the application of the sealing material 33 and the application of the holding material 50 (in either order), the prebaking of the sealing material can double as the vaporization of the volatile material of the holding material, enabling the number of steps to be reduced.

[0082]

The embodiments described above are merely illustrative examples of the present invention, and the configurations thereof may be modified, as appropriate, within the scope of the present invention.

[0083]

EFFECTS OF THE INVENTION

According to the present invention, the conductive material is mixed only into the portion of the bonding material that is sandwiched between the inter-substrate conducting-electrode portions; thus, space can be effectively utilized, and, even if the layer configurations of the electrode substrates differ between the portions in which the inter-substrate conducting electrodes are formed and the remaining portions, the inter-substrate conducting-electrode portions can be reliably electrically connected. In this manner, it is possible to make the non-display region small and achieve reliable conduction between the electrode substrates.

[0084]

In addition, according to the present invention, it is possible to set the dimensions of the conductive particles to greater than the design dimensions between the inter-substrate conducting-electrode portions, deform the conductive particles by applying pressure when the electrode substrates are bonded together, tolerate dimensional errors in the electrode substrates and, reliably create conduction between the inter-substrate conducting electrode portions. In addition, by pressurizing and deforming the conductive particles in a state in which they are sandwiched between the electrode substrates, it is possible to reliably bring the inter-substrate conducting-electrode portions and the conductive particles into surface contact, which also makes it possible to achieve reliable conduction between the inter-substrate conducting-electrode portions.

[0085]

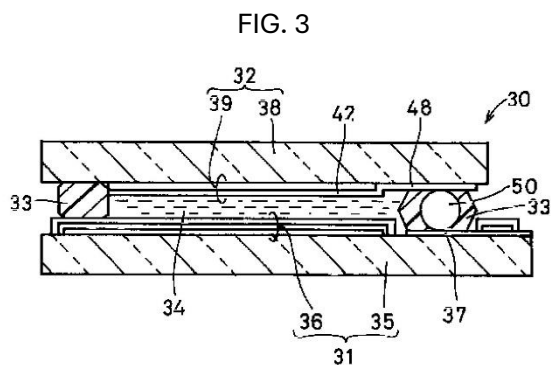
In addition, according to the present invention, the bonding material is provided in a region including on the inter-substrate conducting electrode portion, the holding material into which the conductive material is mixed is provided, and these electrode substrates are disposed so that the inter-substrate conducting electrode portions face each other, and are bonded together by the bonding material to manufacture a display element in which the bonding material is provided at a location at which the material is partially sandwiched between the inter-substrate conducting electrode portions, and the conductive material is mixed only into the portion of this bonding material that is sandwiched between the inter-substrate conducting electrode portions. In this manner, it is possible to easily manufacture a display element in which it is possible to make the non-display region small and achieve reliable conduction between the electrode substrates.

[0086]

In addition, the holding material is composed of a material similar to the bonding material and diluted with a volatile material; thus, if the volatile material vaporizes, the holding material can function similarly to the bonding material, and the bonding together of the electrode substrates by the bonding material is not affected. Moreover, the amount of the holding material after the vaporization of the volatile material can be made small, the dimensions of the bonding material between the inter-substrate conducting electrode portions into which the conductive material is mixed can be kept small, and the non-display region can be kept small.

[0087]

In addition, according to the present invention, the bonding material is provided in a region including on the inter-substrate conducting electrode portion, the holding material into which the conductive material is mixed is provided, and these electrode substrates are disposed so that the inter-substrate conducting electrode portions face each other, and are bonded together by the bonding material to manufacture a display element in which the bonding material is provided at a location at which the material is partially sandwiched between the inter-substrate conducting electrode portions, and the conductive material is mixed only into the portion of this bonding material that is sandwiched between the inter-substrate conducting electrode portions. In this manner, it is possible to easily manufacture a display element in which it is possible to make the non-display region smaller and achieve reliable conduction between the electrode substrates.



[0088]

In addition, the holding material is composed of a volatile material; thus, if the volatile material vaporizes, the holding material can function similarly to the bonding material, and the bonding together of the electrode substrates by the bonding material is not affected. Moreover, the amount of the holding material after the vaporization of the volatile material can be made smaller, the dimensions of the bonding material between the inter-substrate conducting electrode portions into which the conductive material is mixed can be kept small, and the non-display region can be kept small.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view showing a portion of a display element 30 according to one embodiment of the present invention.

FIG. 2 is a cross-sectional view showing the display element 30 as a whole.

FIG. 3 is a cross-sectional view as seen along a cross-sectional line S2-S2 in FIG. 2.

FIG. 4 is an enlarged cross-sectional view showing the vicinity of a common electrode 37 of the display element 30.

FIG. 5 is a flow chart illustrating a manufacturing method for the display element 30.

FIG. 6 is a flow chart showing another manufacturing method for the display element 30.

FIG. 7 is a cross-sectional view showing a portion of a conventional liquid-crystal display element 1.

FIG. 8 is a cross-sectional view showing the liquid-crystal display element 1 as a whole.

FIG. 9 is a cross-sectional view as seen along a cross-sectional line S9-S9 in FIG. 8.

FIG. 10 is a cross-sectional view showing another conventional liquid-crystal display element 1A as a whole.

FIG. 11 is an enlarged cross-sectional view showing the vicinity of a common electrode 9 of the liquid-crystal display element 1A.

EXPLANATION OF THE REFERENCE NUMBERS

30	Display element
31, 32	Electrode substrates
33	Sealing material
37	Common electrode
48	Connection electrode
50	Conductive material

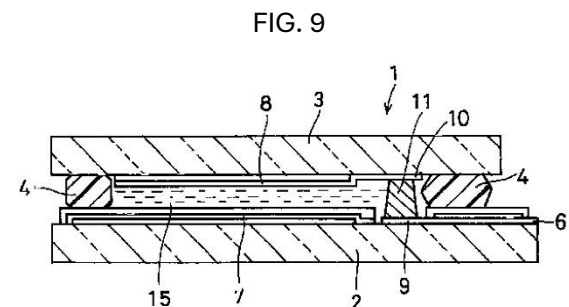


FIG. 1

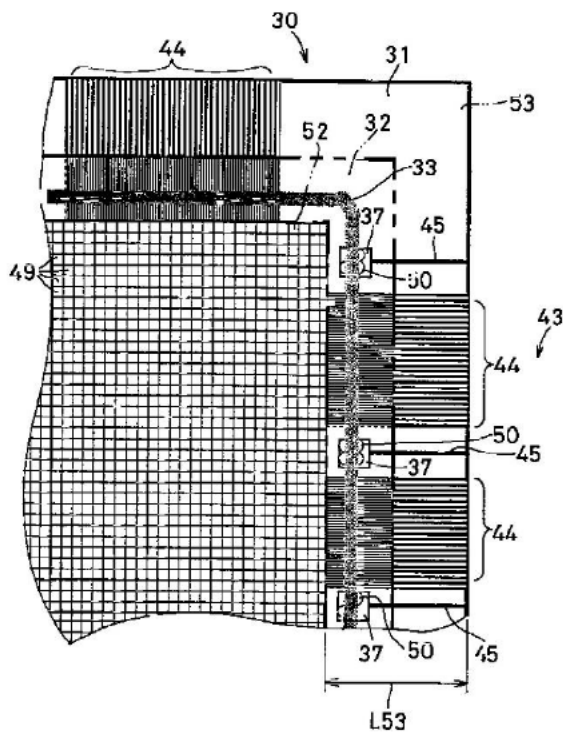


FIG. 2

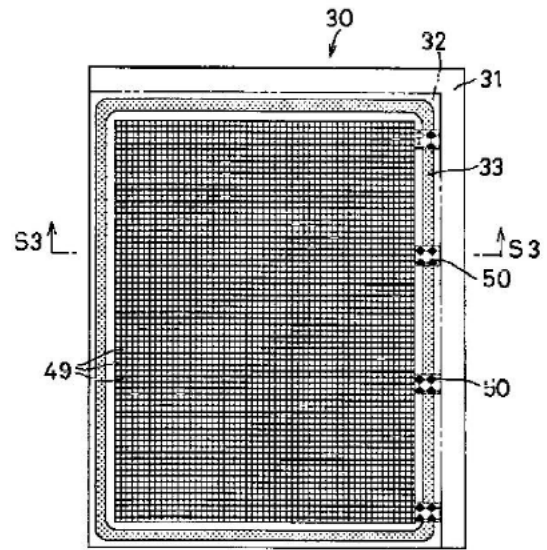


FIG. 5

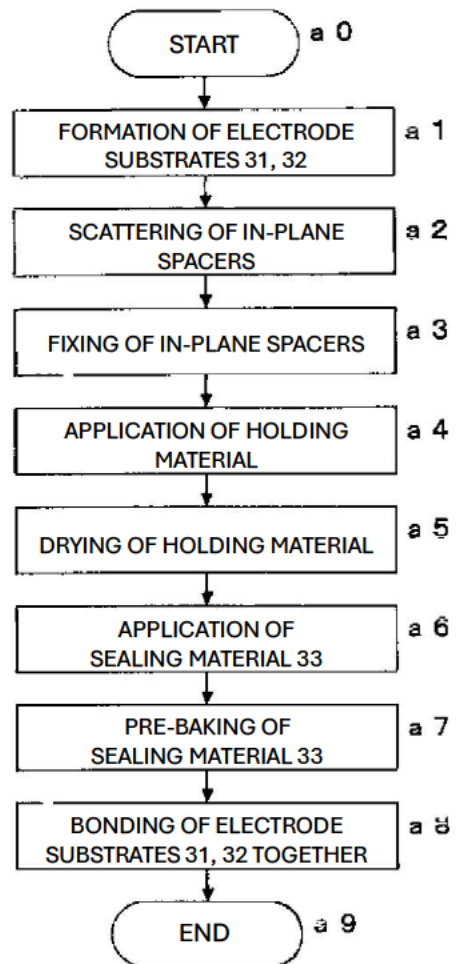


FIG. 4

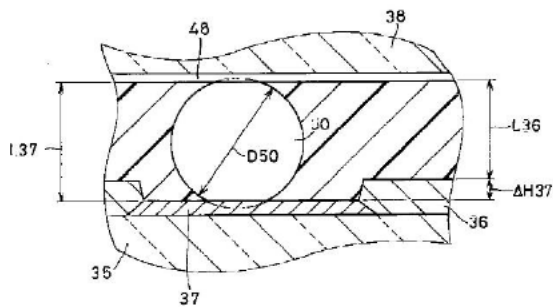


FIG. 6

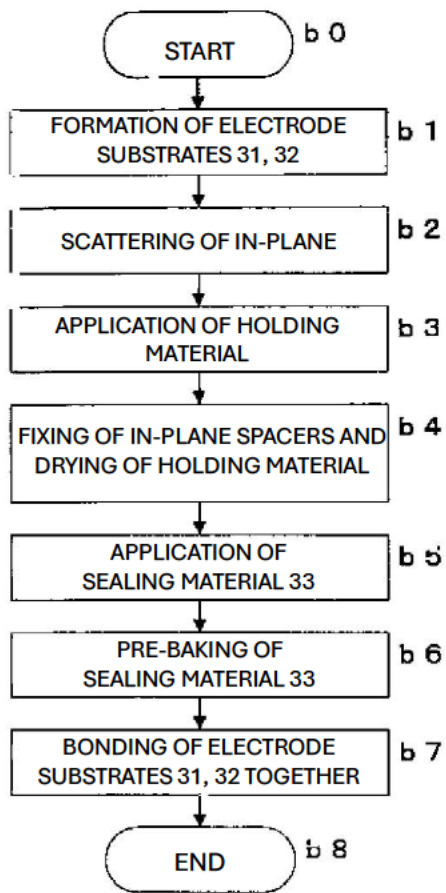


FIG. 8

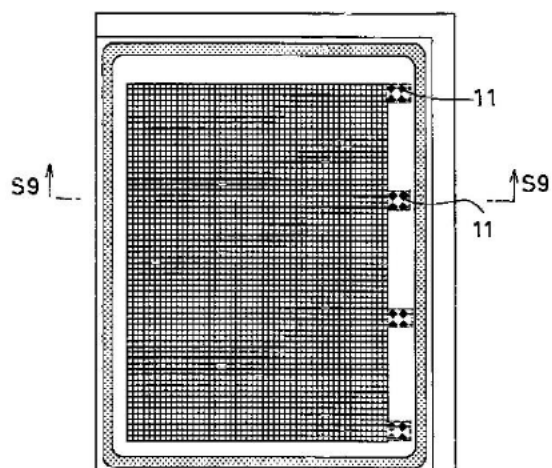


FIG. 7

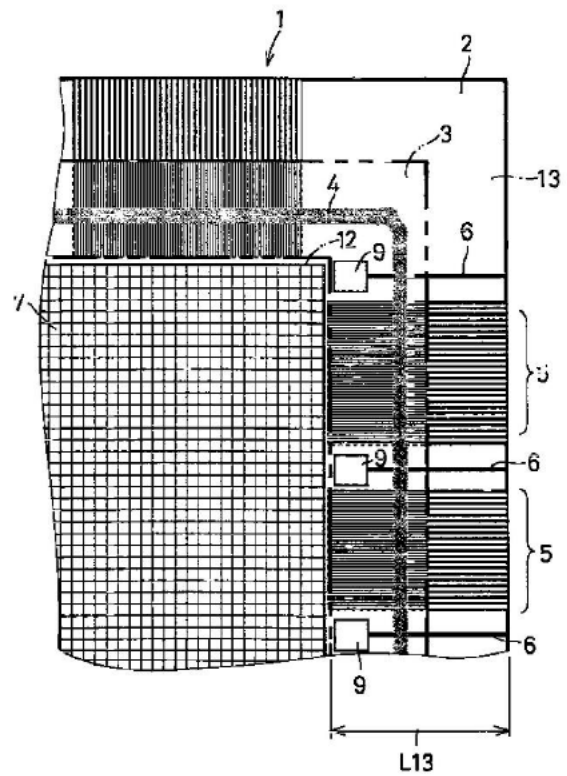


FIG. 10

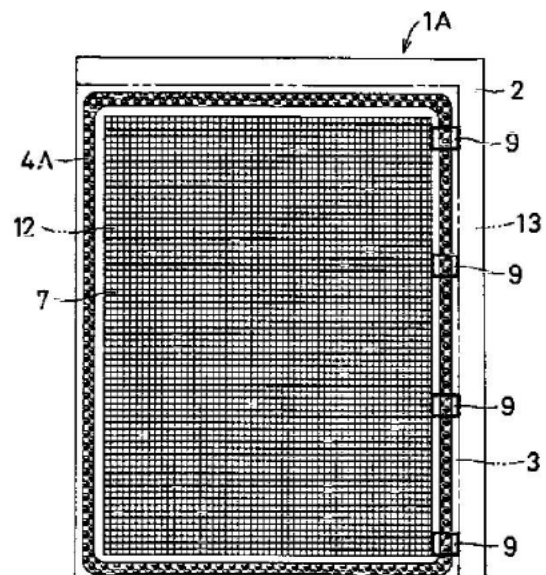
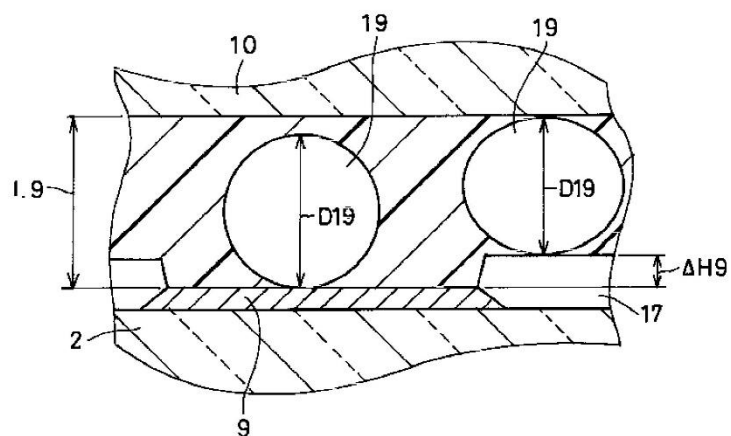


FIG. 11



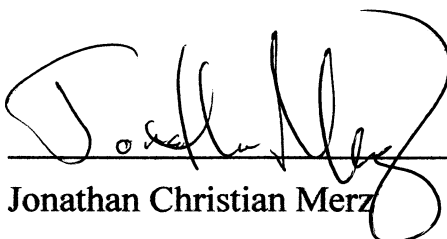
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F-term(s) (reference):	2H089	LA41	MA06Y	PA17	QA11
		QA16	TA02	TA07	
	2H092	GA39	HA13	HA23	NA07 PA04
	5C094	AA14	AA53	BA43	CA19 DA07
		EA02	EC01	FB06	GB01
	5G435	AA17	AA18	BB12	CC09 EE42
		HH12	KK05	LL07	LL08

I, Jonathan Christian Merz, declare as follows:

1. I am over 21 years of age and am competent to make this declaration.
2. I am a native speaker of English.
3. I am fluent in Japanese.
4. I have 15 years of experience translating Japanese to English.
5. I translated the attached patent document "JP2003280030A" from Japanese to English.
6. I certify that the translation of the document "JP2003280030A" is, to the best of my knowledge, a true and accurate translation from Japanese to English.
7. In signing this declaration, I understand that the translation and this declaration may be filed as evidence in a contested case. I acknowledge that I may be subject to cross-examination within the United States.
8. I declare under penalty of perjury that all statements made herein are true and accurate to the best of my knowledge and belief, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed: May 30, 2024

By: 
Jonathan Christian Merz