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(54) Title of Invention
LIQUID-CRYSTAL DISPLAY DEVICE

(57) Abstract

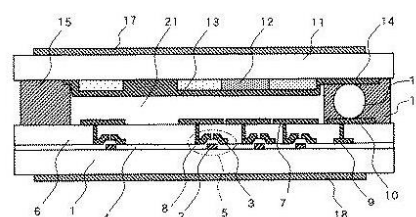
Problem

To improve the corrosion-resistance performance in an electrical-connection portion of an array substrate and a color-filter substrate, and to ensure a low-resistance and stable connection.

Solution

An array substrate 1 and a color-filter substrate 11 pasted together via a seal resin layer 15, and liquid crystal 21 filled in the gap between both substrates, are provided. The array substrate has a pixel electrode 7, a transistor 5, and a common electrode 9, on which a common-electrode pad 10 is formed at one terminal end thereof. The color-filter substrate has a color-filter layer 12, a counter electrode 13 formed on the color-filter layer, and a counter-electrode pad 14 formed opposing the common-electrode pad at a terminal end portion of the counter electrode. A connecting portion, which is opposing the common-electrode pad and the counter-electrode pad, is located in the seal resin layer, electrically conductive particles 16 are dispersed in the seal resin layer, and an electrical connection is made between the common-electrode pad and the counter-electrode pad via the electrically conductive particles.

Selected Figure: FIG. 2



CLAIMS

1. In a liquid-crystal display device provided with: an array substrate; a color-filter substrate pasted together with the array substrate via a seal resin layer with a prescribed gap provided therebetween; and liquid crystal filled in the gap between both substrates; wherein a plurality of pixel electrodes, a thin-film transistor, a source-wiring electrode, a gate-wiring electrode, and a common electrode on which a common-electrode pad is formed on one terminal end are provided on the array substrate; and a color-filter layer, a counter electrode formed on at least the color-filter layer, and a counter-electrode pad formed opposing the common-electrode pad at the terminal end portion of the counter electrode are provided on the color-filter substrate; a liquid-crystal display device wherein:

a connecting portion, which is opposing the common-electrode pad and the counter-electrode pad, is located in the seal resin layer, which is formed between the array substrate and the color-filter substrate, electrically conductive particles are dispersed in the seal resin layer, and an electrical connection is made between the common-electrode pad and the counter-electrode pad via the electrically conductive particles.

2. The liquid-crystal display device according to claim 1, wherein the widths of the common-electrode pad and the counter-electrode pad are less than the width of the seal resin layer.

3. The liquid-crystal display device according to claim 1, wherein the electrically conductive particles are dispersed selectively in the seal resin layer that is in a region opposing the common-electrode pad and the counter-electrode pad.

DETAILED DESCRIPTION OF THE INVENTION**[0001]****TECHNICAL FIELD PERTAINING TO THE INVENTION**

The present invention relates to a color, thin-film-transistor (TFT)-type liquid-crystal display device in which liquid crystal fills in between an array substrate and a color-filter substrate that are pasted together via a seal resin layer.

[0002]**BACKGROUND ART**

Liquid-crystal displays (referred to as LCDs below) have excellent characteristics such as being thin, being lightweight, and having low power consumption, and are employed widely as the display for mobile phones and mobile information terminals. Recently in particular, more and more color TFT-LCDs are being installed with the increasing demand for higher definition and higher resolution mobile phone LCDs. Conventional color TFT-LCDs are used in notebook PCs and in monitors that are used indoors; however, because mobile devices, such as mobile phones, are used in environments where the temperature and humidity change in various ways, color TFT-LCDs are also required to have better than conventional environmental resistance characteristics. For instance, conventional color TFT-LCDs for a PC have an operational environment temperature of 0°C–40°C, while the color TFT-LCDs for mobile devices have one of –20°C–60°C with a demand for better than conventional durability.

[0003]

FIG. 3 depicts one example of a cross-sectional structure of a conventional color TFT-LCD. An array substrate 1 and a color-filter substrate 11 are pasted together by way of a seal resin 15 with a prescribed gap formed therebetween, and the gap is filled with liquid crystal 21.

[0004]

A thin-film transistor 5 is formed on the array substrate 1, and a pixel electrode 7 is formed thereupon via an interlayer insulating film 6 and is connected to a drain electrode 8 of the transistor 5. A common electrode 9 is formed at an end portion of the array substrate 1, and a common-electrode pad 10 is provided at an end portion of the common electrode 9.

[0005]

A color-filter layer 12 is formed on the color-filter substrate 11, and a counter electrode 13 is formed thereupon. A counter-electrode pad 14 is provided at an end portion of the counter electrode 13 at a location opposing the common-electrode pad 10. The common-electrode pad 10 and the counter-electrode pad 14 are electrically connected via a conductive material 22 such as a carbon paste.

[0006]

In a conventional color TFT-LCD, materials, such as aluminum, titanium, and molybdenum, are generally used as the wiring material on the array substrate 1, and primarily ITO is used as the pixel electrode 7 material for a transmissive type, or aluminum is used for the pixel surface entirely or partially for a semi-transmissive type. In addition, ITO is also employed as the counter-electrode material 13 in the color-filter substrate 11. Because generally a drive LSI is installed on the array substrate 1 side, a structure is needed to electrically connect the counter electrode 13 on the color-filter substrate 11 side and the LSI.

[0007]

Therefore, connection wiring (the common electrode 9) and, at the tip portion thereof, an electrode pad (the common-electrode pad 10) are provided on the array substrate 1. In addition, the counter-electrode pad 14 is provided on the color-filter substrate 11 at an end portion of the counter electrode 13. The common-electrode pad 10 and the counter-electrode pad 14 are electrically connected via the conductive material 22 as mentioned above. Normally, the common-electrode pad 10 is disposed outward of the seal resin 15 in order to prevent the electrically conductive substance 22, such as the carbon paste, from diffusing into the liquid crystal 21 (see, for example, Patent Document 1).

[0008]

Patent Document 1

Japanese Laid-open Patent Publication S63-287821

[0009]

PROBLEMS TO BE SOLVED BY THE INVENTION

However, disposing the connecting portion, which is between the common-electrode pad 10 and the counter-electrode pad 14 (this portion is called the transfer portion below), outside the seal resin 15 exposes the connecting portion to the environment. Therefore, in an operating test at 60°C/90% humidity, for example, a phenomenon occurred where the electrode for the transfer portion corroded due to the moisture in the atmosphere, ions (impurities), and the electric field. In a situation in which the transfer portion is constituted by dissimilar metals of aluminum and ITO in particular, this phenomenon occurs very easily, dissolving the aluminum or reducing the ITO, and causing problems such as display abnormalities.

[0010]

An object of the present invention is to improve the corrosion-resistance performance of the transfer portion and curtail the conductive material that is for electrical connection from eluting into the liquid crystal and to provide a liquid-crystal display device capable of ensuring a low-resistance and stable connection.

[0011]

MEANS FOR SOLVING THE PROBLEMS

A liquid-crystal display device of the present invention comprises: an array substrate; a color-filter substrate pasted together with the array substrate via a seal resin layer with a prescribed gap provided therebetween; and liquid crystal filled in the gap between both substrates; wherein a plurality of pixel electrodes, a thin-film transistor, a source-wiring electrode, a gate-wiring electrode, and a common electrode on which a common-electrode pad is formed on one terminal end are provided on the array substrate; and a color-filter layer, a counter electrode formed on at least the color-filter layer, and a counter-electrode pad formed opposing the common-electrode pad at the terminal end portion of the counter-electrode are provided on the color-filter substrate.

[0012]

To solve the above-mentioned problem, it has a configuration in which a connecting portion, which is opposing the common-electrode pad and the counter-electrode pad, is located in the seal resin layer, which is formed between the array substrate and the color-filter substrate, electrically conductive particles are dispersed in the seal resin layer, and an electrical connection is made between the common-electrode pad and the counter-electrode pad via the electrically conductive particles.

[0013]

EMBODIMENTS OF THE INVENTION

According to a liquid-crystal display device of the present invention, the configuration described in the Means for Solving the Problems above provides a common-electrode pad and a counter-electrode pad in a seal resin layer, and the electrical connection is made via electrically conductive particles dispersed in the seal resin layer. Accordingly, the common-electrode pad and the counter-electrode pad are not exposed to an external environment, which avoids both of the electrode pads being directly exposed to

moisture. Thereby, the corrosion-resistance performance of both the electrode pad portions can be improved because the permeation of moisture and ions is prevented. In addition, because the electrical connection is made via the electrically conductive particles dispersed in the seal resin layer, no electrically conductive particles elute into the liquid crystal, and a low-resistance and stable connection can be ensured.

[0014]

The widths of the common-electrode pad and the counter-electrode pad are preferably less than the width of the seal resin layer. According thereto, both of the above-mentioned electrode pads do not jut further outward than the seal resin, and therefore, are not exposed directly to moisture, and thus corrosion-resistance performance can be improved.

[0015]

In addition, the electrically conductive particles are preferably also dispersed selectively in the seal resin layer that is in a region opposing the common-electrode pad and the counter-electrode pad.

[0016]

A specific embodiment of a liquid-crystal display device of the present invention is described below with reference to the drawings.

[0017]

(Embodiments)

FIG. 1 is a plan view illustrating a configuration of a liquid-crystal display device in one embodiment of the present invention; FIG. 2 is a cross-sectional view of the A-A portion in FIG. 1. However, the A-A cross section is diagrammed conceptually, ignoring dimensional conformity with FIG. 1 to illustrate the structure of the A-A cross section in a manner that is easy to understand. With regard to elements that are the same as the elements in the conventional example of FIG. 3, the same reference numerals are added and described. The structure of the transfer portion, which is opposing the common-electrode pad 10 and the counter-electrode pad 14 of this liquid-crystal display device, differs from the conventional example, and this liquid-crystal display device is described below. First, the overall structure of this liquid-crystal display device will be described.

[0018]

1 is an array substrate composed of alkali-free glass, and 11 is a color-filter substrate composed of alkali-free glass; the array substrate and the color-filter substrate are pasted together by way of a seal resin 15 composed of a thermosetting resin so that a prescribed gap is formed therebetween with the same opposing each other, and that gap is filled with liquid crystal 21.

[0019]

Gate electrodes 2 and source electrodes, which are made from aluminum and titanium, are disposed in a matrix shape on the array substrate 1 via an interlayer insulating film 4, which is made from silicon nitride. A transistor 5 having an amorphous-silicon layer is formed at each intersection point of the gate electrode 2 and the source electrode 3. A pixel electrode 7, which is composed of ITO, is formed on each transistor 5 via an interlayer insulating film 6, and is electrically connected to a drain electrode 8 of the transistor 5. A common electrode 9, which is composed of aluminum and titanium, is formed at an end portion of the array substrate 1, and a common-electrode pad 10 is provided at an end portion of the common electrode 9. Each of the gate electrodes 1 and the source electrodes 3 are connected to a gate-side LSI 19 and a source-side LSI 20.

[0020]

Color-filter layers 12, for each of R, G, and B, are provided on the opposing-side color-filter substrate 11, and a counter electrode 13, which is made from ITO, is formed on each of the color-filter layers 12. The counter-electrode pad 14 is provided at a location opposing the common-electrode pad 10, at an end portion of the counter electrode 13.

[0021]

Electrically conductive particles 16, which are metal-plated resin balls, are dispersed through the seal resin 15 at a location opposing the common-electrode pad 10 and the counter-electrode pad 14, and the transfer portion is thus formed. Note that the size of the electrically conductive particles 16 is exaggerated for diagramming; however, the size of the electrically conductive particles employed should be on the order normally employed to impart conductivity thereto. The structure of the transfer portion in which the electrically conductive particles 16 are dispersed electrically connects the common-electrode pad 10 and the counter-electrode pad 14.

[0022]

Note that while not shown, an alignment layer is formed on the pixel electrode 7 and the counter electrode 13, and the rubbing thereof is in a prescribed direction. In addition, as shown in FIG. 2, a lower-side polarizing plate 18 and an upper-side polarizing plate 17 are provided at the outer-surface side of the array substrate 1 and the color-filter substrate 11, respectively.

[0023]

To form the transfer portion, the seal resin 15, in which the electrically conductive particles 16 that are metal-plated resin balls are dispersed, is selectively applied to only the common-electrode pad 10 on the array substrate 1. In addition, on the opposing color-filter substrate 11, the seal resin 15 that does not include electrically conductive particles is applied to the outer-peripheral portion of the pixel electrode 7. Thereafter, the array substrate 1 and the color filter 11 substrate are pasted together, and thereby the common-electrode pad 10 and the counter-electrode pad 14 are electrically connected via the electrically conductive particles 16. Because the electrically conductive particles 16 are buried throughout the hardened seal resin 15, the electrically conductive particles 16 do not elute into the liquid crystal 21.

[0024]

As shown in FIG. 2 (A-A cross-sectional view of FIG. 1), the common-electrode pad 10 and the counter-electrode pad 14 are formed to be smaller than the planar outline of the seal resin 15, and thus do not jut outward from the seal resin 15 and are not exposed to the external environment.

[0025]

A liquid-crystal display device configured on the basis of the present embodiment was subjected to continuous energization at 60°C/90% humidity, and even after 1,000 hours had elapsed, it was confirmed that no corrosion occurred on the common-electrode pad 10 and the counter-electrode pad 14 portions. Meanwhile, because corrosion occurred in the liquid-crystal display device having a conventional configuration at approximately 250 hours, an approximately four-fold improvement in corrosion resistance could be confirmed.

[0026]

With regard to connection resistance as well, the same was stable at less than or equal to 10 Ω initially and after 1,000 hours had elapsed, and no display abnormalities due to connection defects were observed.

[0027]

While the present embodiment described a situation in which the seal resin 15, which has the electrically conductive particles 16 dispersed therein, is selectively applied to the common-electrode pad 10 on the array substrate 1, the present invention is applicable without necessarily being limited to this structure. For example, as long as no electrical short circuit would occur between the source electrode 3 or the gate electrode 2 of the array substrate 1 and the counter electrode 13 of the opposing color-filter substrate 11, the same effect can be obtained by forming the seal resin 15, which has the electrically conductive particles 16 dispersed therein, on the entire periphery of the array substrate 1 so as to include the common-electrode pad 10, or on the entire periphery of the color-filter substrate 11 so as to include the counter-electrode pad 10.

[0028]

In addition, while a configuration with regard to the situation of a transmissive-type color TFT-LCD is described in the present embodiment, the present invention can be similarly applied even for reflective-type or semi-transmissive-type color TFT-LCDs as well. In the situation of a reflective-type or semi-transmissive-type color TFT-LCD, the pixel electrode 7 and the common-electrode pad 10 are constituted from aluminum, and the common-electrode pad 10 and the counter-electrode pad 14 each are dissimilar-metal junctions of aluminum and ITO. With regard to dissimilar-metal junctions, corrosion tends to occur due to the occurrence of differences in activation energies. Accordingly, it is more effective to improve the corrosion resistance of aluminum, in which positive-electrode corrosion tends to occur easily, by way of the configuration of the present invention.

[0029]**EFFECTS OF THE INVENTION**

According to a liquid-crystal display device of the present invention, because the connecting portion, which is opposing the common-electrode pad and the counter-electrode pad, is located in the seal resin formed on the array substrate or the color-filter substrate, the corrosion resistance of the common-electrode pad and the counter-electrode pad can be improved. In addition, the common-electrode pad and the counter electrode pad are electrically connected via electrically conductive particles dispersed in a seal resin layer, thereby curtailing the elution of the electrically conductive particles into the liquid crystal and ensuring a low-resistance and stable connection.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a liquid-crystal display device of one embodiment of the present invention.

FIG. 2 is a cross-sectional view of the A-A portion in FIG. 1.

FIG. 3 is a cross-sectional view of a liquid-crystal display device of a conventional example.

EXPLANATION OF THE REFERENCE NUMBERS

- 1 Array substrate
- 2 Gate electrode
- 3 Source electrode
- 4 Interlayer insulating film
- 5 Transistor
- 6 Interlayer insulating film
- 7 Pixel electrode
- 8 Drain electrode
- 9 Common electrode
- 10 Common-electrode pad
- 11 Color-filter substrate
- 12 Color-filter layer
- 13 Counter electrode
- 14 Counter-electrode pad
- 15 Seal resin
- 16 Electrically conductive particle
- 17 Upper-side polarizing plate
- 18 Lower-side polarizing plate
- 19 Gate-side LSI
- 20 Source-side LSI
- 21 Liquid crystal
- 22 Carbon paste

FIG. 1

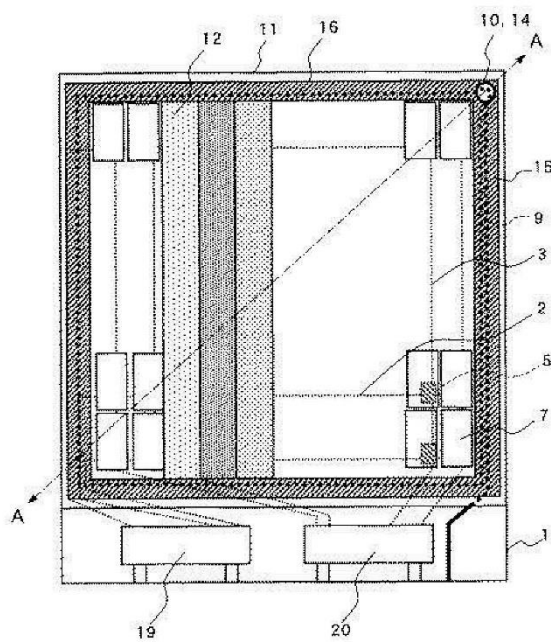


FIG. 2

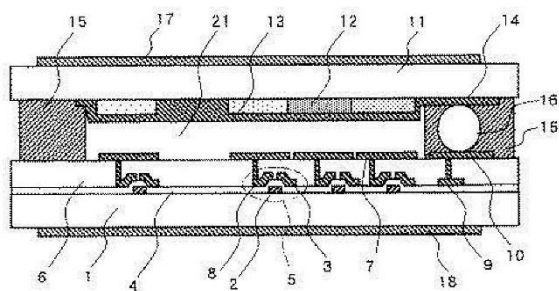
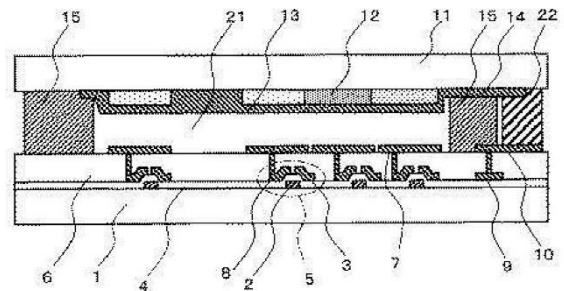


FIG. 3



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I, Nadine A. Edwards, 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 14 years of experience translating Japanese to English.
5. I translated the attached patent document "JP2004226654A" from Japanese to English.
6. I certify that the translation of the document "JP2004226654A" 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: June 6, 2024

By: 
Nadine A. Edwards