



(12) **United States Patent**
Yamamoto

(10) **Patent No.:** **US 6,566,154 B2**
(45) **Date of Patent:** **May 20, 2003**

(54) **METHOD FOR MANUFACTURING LIQUID CRYSTAL DISPLAY DEVICE**

(75) Inventor: **Yuji Yamamoto, Izumi (JP)**

(73) Assignee: **NEC Corporation, Tokyo (JP)**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/160,071**

(22) Filed: **Jun. 4, 2002**

(65) **Prior Publication Data**

US 2002/0182766 A1 Dec. 5, 2002

(30) **Foreign Application Priority Data**

Jun. 4, 2001 (JP) 2001-168009

(51) **Int. Cl.**⁷ **H01L 21/00; H01L 21/84**

(52) **U.S. Cl.** **438/30; 438/149; 438/155**

(58) **Field of Search** **438/30, 149-166**

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,834,327 A * 11/1998 Yamazaki et al. 438/30
6,413,838 B2 * 7/2002 Itoh 438/462

2002/0030189 A1 * 3/2002 Ishikawa 257/59
2002/0094639 A1 * 7/2002 Reddy 438/257
2002/0102783 A1 * 8/2002 Fujimoto et al. 438/200
2002/0110944 A1 * 8/2002 Kian et al. 438/30
2002/0187594 A1 * 12/2002 Yamazaki et al. 438/166

FOREIGN PATENT DOCUMENTS

JP 9-116158 5/1997
JP 11-212116 8/1999

* cited by examiner

Primary Examiner—John F. Niebling
Assistant Examiner—Jennifer M. Kennedy
(74) *Attorney, Agent, or Firm*—Young & Thompson

(57) **ABSTRACT**

A plastic substrate is employed as a counter substrate that constitutes one of two substrates of a liquid crystal panel. To form such a liquid crystal panel, the counter substrate consisting of the plastic substrate is manufactured in a situation where a glass substrate is adhered to the plastic substrate as a support substrate for the plastic substrate in the steps ranging from the step for forming the common electrode on the plastic substrate to the step prior to the step for cutting and dividing the counter substrate into the liquid crystal panel units. Accordingly, the plastic substrate can be processed in the same method as that could be employed to process a glass substrate.

6 Claims, 4 Drawing Sheets

MANUFACTURING STEP FLOW OF LIQUID CRYSTAL DISPLAY PANEL

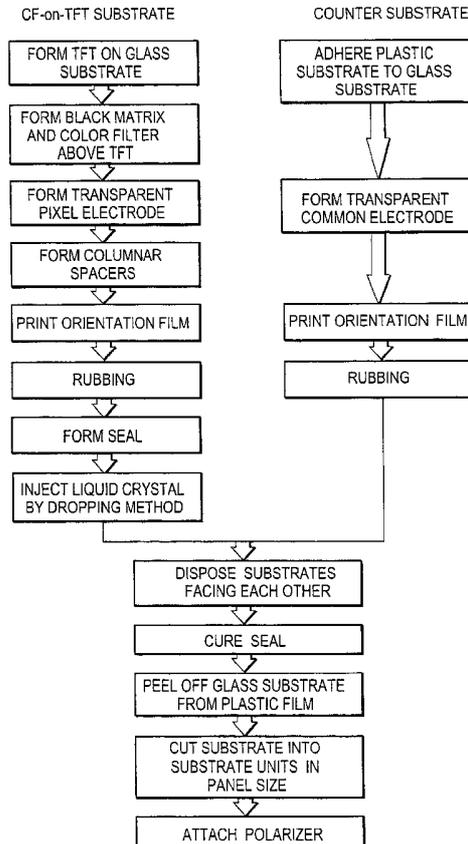


Fig.1

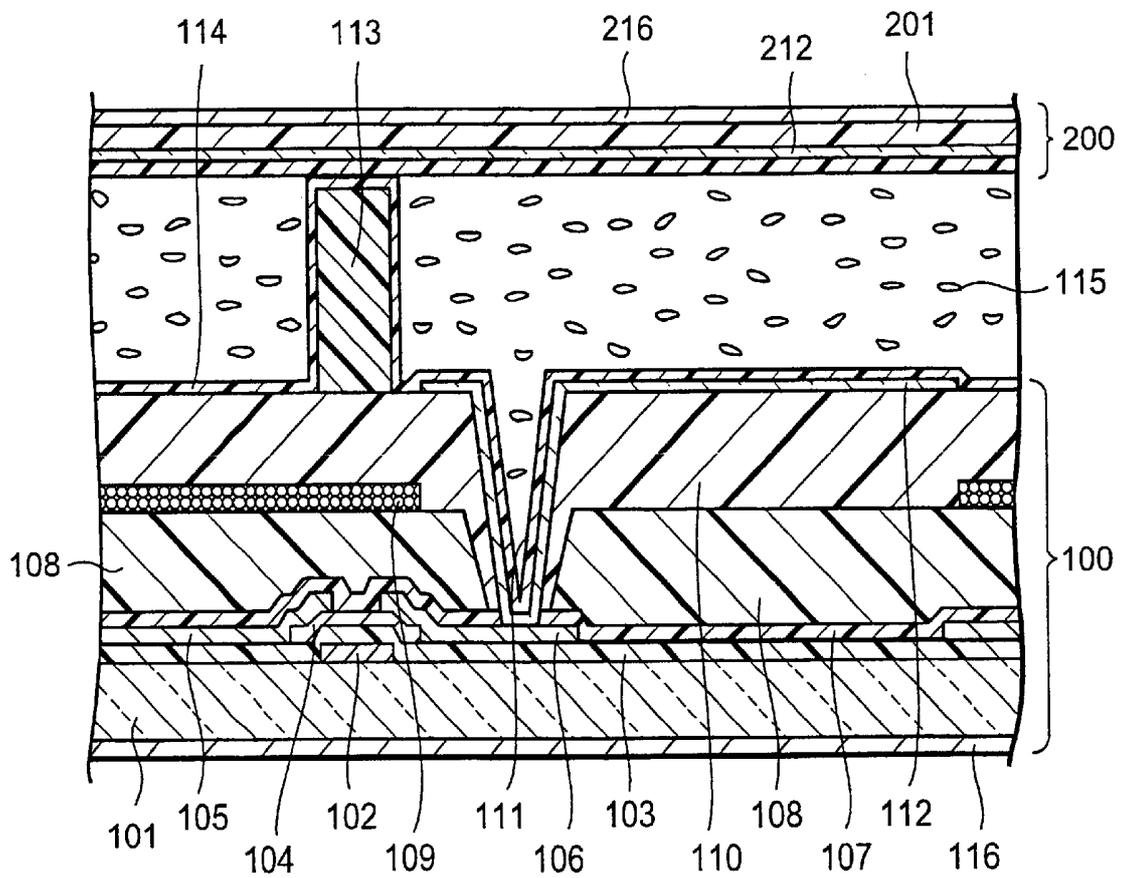


Fig.2

MANUFACTURING STEP FLOW OF LIQUID CRYSTAL DISPLAY PANEL

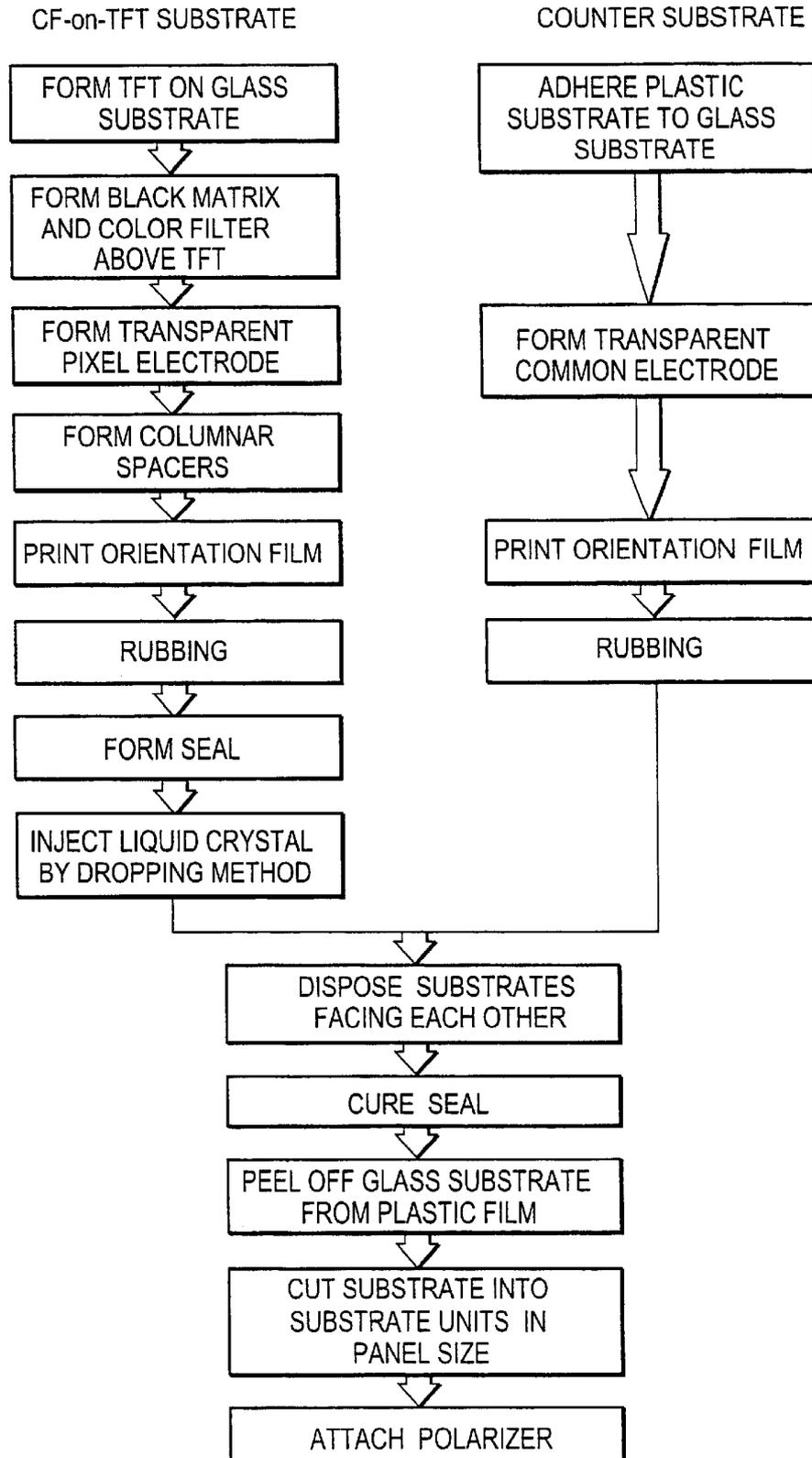


Fig.3

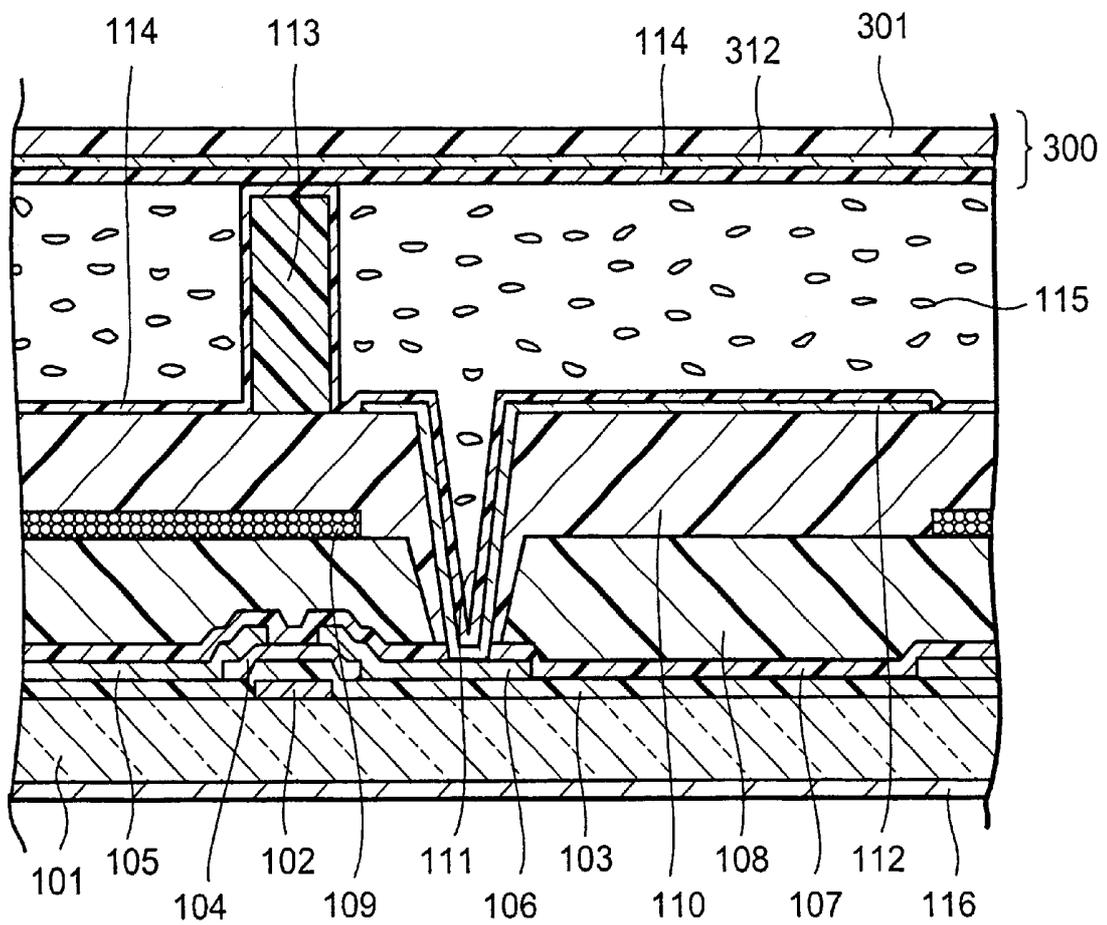
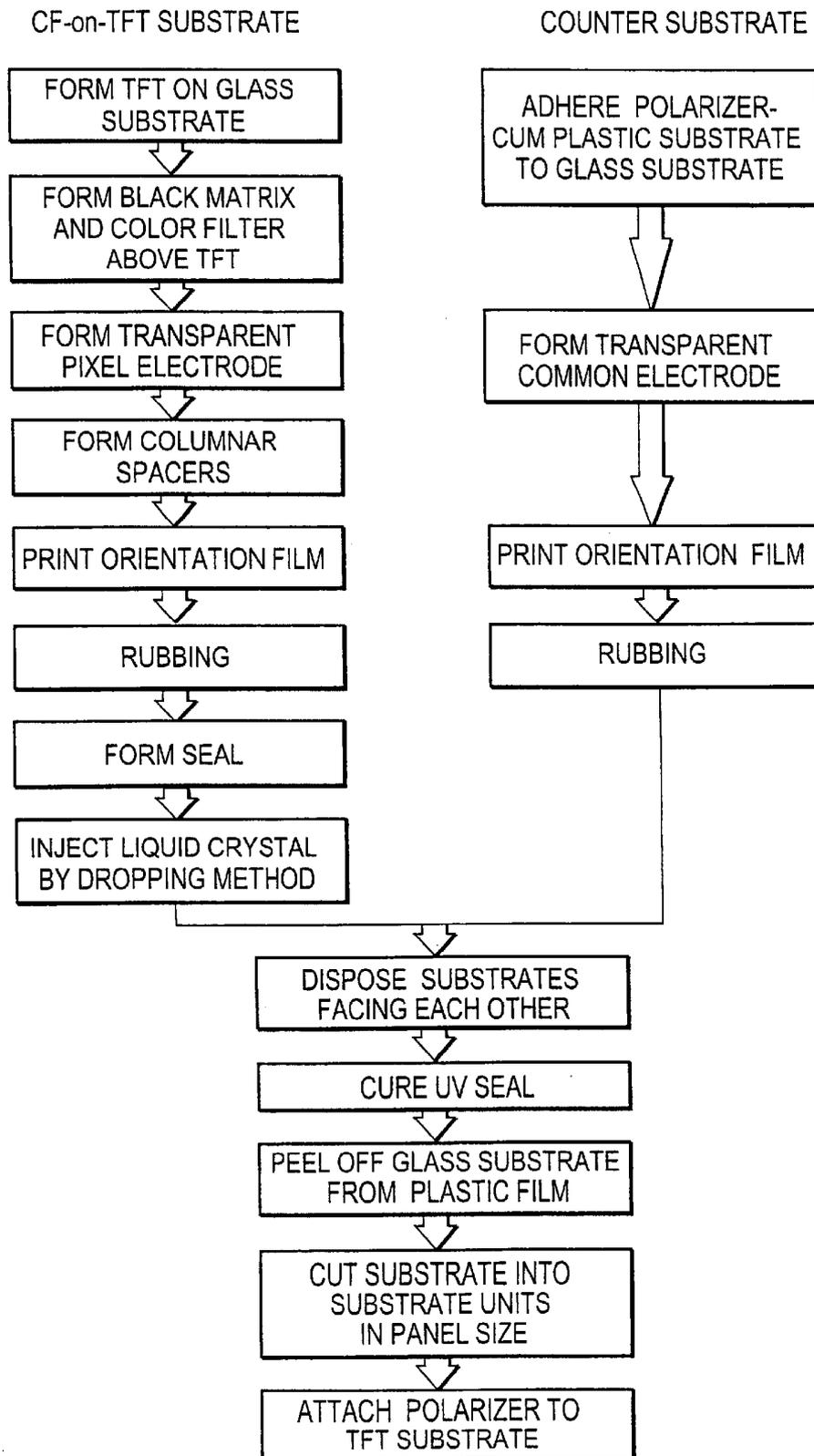


Fig.4

MANUFACTURING STEP FLOW OF LIQUID CRYSTAL DISPLAY PANEL



METHOD FOR MANUFACTURING LIQUID CRYSTAL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method for manufacturing a liquid crystal display device, and more particularly to a method for manufacturing a liquid crystal display device that employs a plastic substrate to make a liquid crystal panel lighter and thinner.

2. Description of the Related Art

In terms of actual use of a liquid crystal display device, particularly a portable information terminal device or a portable telephone employing the liquid crystal display device therein, one of critical problems to be solved is to make a liquid crystal panel light-weighted and thin.

Efforts have been vigorously made to overcome such problems by reducing the density of a glass substrate or by making the thickness of the glass substrate thin. When glass density is reduced, a silicon dioxide (SiO_2) mainly constituting a glass decides substantially all physical property values of glass and hence, a technique to further lower the glass density faces its limit, resulting in difficulty in further reducing the glass density. On the other hand, when the plate thickness is made thin, the strength of the glass substrate is drastically degraded so that facilities in a manufacturing line are to forcibly be changed to a large extent and further, the physical resistance against external forces becomes lowered. Accordingly, it is said that the thickness of the glass substrate can at most be made 0.4 to 0.5 mm as its minimum value.

As a liquid crystal panel achieving lightness and thin structure thereof, a so-called simple-matrix-type monochrome liquid crystal panel not employing active elements such as a TFT (Thin Film Transistors) for driving liquid crystal is exemplified. In such a liquid crystal panel, material which constitutes a matrix is formed of transparent electrode material referred to as ITO and is formed at a relatively low temperature and hence, it is possible to use a plastic substrate or the like as a base substrate on which the transparent electrode material is formed. Actually, the plastic substrate having such construction has been used in the portable information terminal device and the portable telephone.

As for a trend of the liquid crystal display panel, there has been observed a phenomenon that an amount of information which can be processed as display information has been increasing in accordance with improvement in performances of the recent portable terminal equipment and then, the image to be displayed has been changing from a monochrome one and a still picture to a color one and a motion picture, respectively.

However, the simple matrix-type liquid crystal display device employs an STN (Super Twisted Nematic) liquid crystal mode as a liquid crystal driving mode and hence, the simple matrix-type liquid crystal display device has the following disadvantages. That is, comparing with an active matrix type liquid crystal display device, which employs a TN (Twisted Nematic) liquid crystal mode and TFTs, and is used in a notebook type personal computer or a monitor, both being popularly and widely used, the simple matrix-type liquid crystal display device does not provide a user with sufficient quality of images to be displayed, so that gray-scale display deteriorates or the user feels residual images

In consideration of the above-described problems, the following techniques have been developed and are disclosed such as in Japanese Laid-open Patent Publication 212116/1999 and Japanese Laid-open Patent Publication 116158/1997. That is, active elements such as a TFT element are formed on a plastic substrate. In the former publication, the active elements are formed on a glass substrate and then, a plastic substrate is attached to the surface of the glass substrate on a side thereof on which the elements are located, and further, a portion of the glass substrate on a side thereof on which the elements are not located, is polished in a direction of the thickness of the substrate to remove the glass substrate. In the latter publication, active elements are formed on a plastic substrate or a glass substrate having a thickness of not greater than 0.5 mm. However, many technical problems to be solved still have been found in a device employing a plastic substrate and further, such device requires expensive facilities, thereby preventing the device from being put into practical use.

In a liquid crystal display device having color filters together with active elements on a plastic substrate, the plastic substrate on which the color filters are formed exhibits the poor resistance against heat and solvent and hence, pigments and solvents available for use as a color filter are limited, whereby the color reproducibility cannot sufficiently be achieved. Accordingly, development of a liquid crystal display device having the following construction and advantages has been strongly required. That is, a liquid crystal display device is formed lighter and thinner, and further formed to operate in the same manner as in a case where a color and active matrix liquid crystal panel operates in a TN liquid crystal mode.

Furthermore, even in a case where a plastic substrate is employed to make a liquid crystal display device lighter and thinner, the plastic substrate has problems other than poor resistance against heat and solvent in that the plastic substrate is easily deformed and therefore, it is so difficult to process the plastic substrate in steps for manufacturing a liquid crystal panel compared to the case where a glass substrate is processed.

SUMMARY OF INVENTION

Accordingly, it is an object of the present invention to provide a method for manufacturing a liquid crystal display device in which a TFT substrate is employed and a liquid crystal can be formed simultaneously lighter and thinner.

A method for manufacturing a liquid crystal display device according to the present invention is constructed as follows. That is, the method comprises:

a step for disposing a TFT substrate and a counter substrate facing the TFT substrate apart a predetermined distance from each other; and

a step for filling a space between the TFT substrate and the counter substrate with a liquid,

in which the liquid crystal display device is constructed such that at least one of the TFT substrate and the counter substrate consists of a plastic substrate, the method further being constructed such that the method comprises a substrate separation step for cutting and dividing a combined substrate consisting of the TFT substrate and the counter substrate, both substrates interposing the liquid crystal therebetween, into substrate units, and one of surfaces of the plastic substrate is supported by a support substrate until the combined substrate is cut and divided.

As described above, by using a plastic substrate as one of two substrates that constitute a liquid crystal panel in a

method for manufacturing a liquid crystal display device, compared to a case in which a glass substrate having a thickness equal to that of the plastic substrate is used in a liquid crystal panel., the liquid crystal panel can be made light-weighted. Furthermore, in a case where the plastic substrate is made to have the same resistance against collision as that of the glass substrate, the thickness of the plastic substrate can be reduced compared to that of the glass substrate, thereby allowing a liquid crystal panel to have a thinner thickness.

The above-described method has the following detailed construction. That is, a method for manufacturing the TFT substrate comprises:

- a step for forming a thin film transistor and a wiring on a first substrate;
 - a step for depositing a protective film covering the thin film transistor and the wiring on the first substrate;
 - a step for forming a color layer corresponding to the thin film transistor and a black matrix shielding light from being irradiated onto the thin film transistor on the protective film;
 - a step for depositing a flattening film covering the color layer and the black matrix on the protective film;
 - a step for opening a part of the protective film and the flattening film to form a contact hole reaching a source electrode of the thin film transistor in the protective film and the flattening film;
 - a step for forming a transparent pixel electrode covering the contact holes and connected to the source electrode on the the flattening film;
 - a step for forming a spacer on the flattening film;
 - a step for forming an orientation film covering the transparent pixel electrode and the spacer on the flattening film, and subsequently, rubbing the orientation film;
 - a step for forming a seal material to surround a predetermined region on the orientation film; and
 - a step for dropping a liquid crystal into the region surrounded by the seal material constituting the orientation film, and
- a method for manufacturing the counter substrate comprises:
- a step for covering a second substrate with a transparent electrode and adhering a support substrate to a surface of the second substrate, the surface being located on a side of the second substrate opposite to the transparent electrode; and
 - a step for forming a material for an orientation film on the transparent electrode, and sequentially, rubbing the orientation film, and
- the method for manufacturing a liquid crystal display device further comprises:
- a step for disposing the TFT substrate and the counter substrate overlapping each other such that the orientation films of the TFT substrate and the counter substrate face each other, and then, making the orientation film of the counter substrate contact the spacer and the seal material of the TFT substrate;
 - a step for curing the seal material to make the TFT substrate and the counter substrate adhere to each other, thereby forming a semi-completed panel;
 - a step for removing the second substrate from the support substrate,
 - a step for cutting and dividing the semi-completed panel into panel units; and
 - a step for attaching a polarizer to a surface of at least the first substrate out of the first and second substrates

constituting the panel unit, the surface being located opposite to the liquid crystal, and the support substrate being previously attached to a surface of the second substrate, the surface being located opposite to the transparent electrode, before the step for forming the transparent electrode on the second substrate.

Furthermore, the above-described detailed method has the following additional construction. That is, the polarizer is attached only to the surface of the first substrate in the step for attaching a polarizer to a surface of at least the first substrate out of the first and second substrates constituting the panel unit, the surface of at least the first substrate being located opposite to the liquid crystal, and the second substrate is formed of a polarizer-cum-plastic substrate.

As described above, employing a polarizer-cum-plastic substrate as the second substrate out of the first and second substrates makes it possible to form a second substrate thinner than that could be achieved by use of a glass substrate and thereby form a liquid crystal panel further thinner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a liquid crystal panel formed using the first embodiment of the present invention;

FIG. 2 is a manufacturing step flow chart, which shows a method for manufacturing a liquid crystal display device of the first embodiment of the present invention;

FIG. 3 is a cross-sectional view of a liquid crystal display device formed using the second embodiment of the present invention; and

FIG. 4 is a manufacturing step flow chart, which shows a method for manufacturing a liquid crystal display device of the second embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The first embodiment of the present invention will be explained referring to FIG. 1. FIG. 1 is a cross-sectional view of a liquid crystal panel, cut along a plane passing just through a TFT on a TFT substrate, the plane being perpendicular to the substrate.

As shown in FIG. 1, a color filter **108** and a black matrix **109** are formed on a TFT through exposure or the like and a pixel electrode **112** and a columnar spacer **113** are formed on the color filter and the black matrix via an overcoat **110**, thereby forming a TFT substrate **100**. A counter substrate **200** facing the TFT substrate **100** is formed by forming a counter electrode **212** on a plastic substrate **201**.

With the use of the plastic substrate **201**, compared to a case in which a glass substrate having a thickness equal to that of the plastic substrate **201** is used, the liquid crystal panel can be made light-weighted. Furthermore, in a case where the plastic substrate **201** is made to have the same resistance against collision as that of the glass substrate, the thickness of the plastic substrate can be reduced compared to that of the glass substrate, thereby allowing a liquid crystal panel to have a thinner thickness.

An amorphous silicon (a-Si) layer **104** is formed on a glass substrate **101** of the TFT substrate **100**. On the a-Si layer **104** are formed the color filter **108** and the black matrix **109**, and the overcoat **110** is further formed covering the color filter and the black matrix. Further, in a contact hole **111** formed in the overcoat **110** is formed the pixel electrode **112** made of a transparent metal. The TFT substrate **100** having the above-mentioned films are disposed facing the

counter substrate **200** via the columnar spacer **113** while being spaced a distance of several micron meters apart from the counter substrate and interposing a liquid crystal **115** between the TFT substrate **100** and the counter electrode **200**.

In the liquid crystal panel constructed as described above, the plastic substrate **201** is made of polycarbonate, polyethersulfone, polyarylate or the like. Since the plastic substrate **201** exhibits specific gravity smaller than that of a glass substrate having the same thickness as that of the plastic substrate, the liquid crystal display device can be made light-weighted. Furthermore, in a case where the plastic substrate is made to have the same resistance against collision as that of the glass substrate, the thickness of the plastic substrate can be reduced compared to that of the glass substrate, thereby allowing a liquid crystal panel to have a thinner thickness.

The counter substrate employing the plastic substrate **201** of this embodiment is assembled into a panel through manufacturing steps shown in FIG. 2. One exemplified method for manufacturing a liquid crystal panel having a plastic substrate as a counter substrate will be explained referring to FIG. 1.

First, in the TFT substrate **100**, a gate electrode **102**, a gate insulation film **103**, an a-Si layer **104**, a data line **105** and a source electrode **106**, a passivation film **107**, a color filter **108**, a black matrix **109**, an overcoat **110**, a contact hole **111** and a pixel electrode **112** made of a transparent metal are sequentially formed on the glass substrate **101**.

In the TFT substrate **100**, before forming the pixel electrode **112**, a color resist made of a photosensitive acrylic resin is applied using a spin coating method or a printing method to form the color resist to have uniform film thickness and, thereafter, exposure, development and baking are performed with respect to respective colors thus sequentially forming the color filters **108** at given positions.

Subsequently, a black resist made of a photosensitive acrylic resin is coated on a predetermined area using a coating method similar to that of the color resist and is patterned to form the black matrix **109**.

Subsequently, a transparent resist as an overcoat (organic interlayer insulation film) **110** made of a photosensitive acrylic resin is coated on a predetermined area using a coating method similar to that of the color resist and the contact hole **111** is formed by opening a portion of the overcoat **110** together with the passivation film **107** on the source electrodes **106**. Then, the pixel electrode **112** made of a transparent metal is formed covering the contact hole **111** to connect the pixel electrode **112** and the source electrode **106** to each other.

Furthermore, photosensitive acrylic resin having a film thickness substantially equal to a gap necessary for formation of a panel is coated on the overcoat **110** and is temporarily baked at a temperature of 60 to 120 degree centigrade, and is subjected to exposure using a mask to form a predetermined pattern in the resin. Thereafter, the exposed resin is subjected to development and then, to baking at a temperature of 200 to 250 degree centigrade to form a columnar spacer **113** having a predetermined profile.

A method for manufacturing the counter substrate **200** is explained hereinafter.

First, a plastic substrate **201** having a film thickness of 0.1 to 0.7 mm is fixed to a glass substrate having a plate thickness of 0.4 to 1.1 mm (not shown) by adhesive bonding, negative pressure suction (method for generating negative pressure to suction the plastic substrate) or the like. A

thickness of the glass substrate is optionally selected such that an aggregate thickness of the glass and plastic substrates after the plastic substrate is attached to the glass substrate does not require a specific modification of manufacturing steps. Furthermore, when the glass substrate and the plastic substrate are adhered to each other, a re-peelable pressure sensitive adhesive (pressure-sensitive adhesive which facilitates peel-off) such as a cellophane tape or a seal selected from a group of materials such as a natural-rubber-based adhesive, an acrylic adhesive, a synthetic-rubber-based adhesive, a silicone-based adhesive is applied to a surface of the glass substrate on a side thereof on which an adhesive should be located by a spin coating, a printing method or the like and, thereafter, the plastic substrate **201** is adhered to the glass substrate. Note that silicone or the like may be applied to a surface of the plastic substrate **201** on which an adhesive should be located to facilitate peeling off performed in a later step. Furthermore, the glass substrate and the plastic substrate **201** are not required to have the same area and the plastic substrate **201** may be made slightly larger than the glass substrate to facilitate the peeling off in a later step.

Subsequently, the common electrode **212** made of a transparent metal is formed on the plastic substrate **201** by performing a vacuum sputtering or by applying a transparent resist containing ITO particles or the like to the plastic substrate **201**. In this case, the heat treatment for transforming the deposited or applied film from the amorphous state to the crystalline state is performed at a temperature of not greater than the heat-resistant temperature of the plastic substrate **201** regardless of a state of film, i.e., during and after formation of film.

Subsequently, a method for assembling the TFT substrate **100** and the counter substrate **200** in manufacturing steps of panel is explained.

First, a material made of polyimide or the like for an orientation film is uniformly applied by printing, coating or the like to predetermined areas to have a predetermined film thickness and, then, baked, the predetermined areas being the surfaces of the TFT substrate **100** and the counter substrate **200** on sides thereof on which a liquid crystal located, in more detail, on which the pixel electrode **112** and the common electrode **212** are located, respectively. In this case, the baking is performed at a temperature of not greater than the heat-resistant temperature of plastic at least with respect to the plastic substrate **201**.

Subsequently, to align the liquid crystal in a constant direction, the materials for the orientation films formed on the surfaces of respective substrates are rubbed with a cloth or the like so as to form the orientation films **114** (rubbing treatment).

Thereafter, a seal material of an ultraviolet curing type is drawn on the TFT substrate **100** by a dispenser method and the liquid crystal **115** is filled in a region surrounded by the seal by injecting the liquid crystal using a dropping technique. Although an example in which the seal is formed on the TFT substrate **100** and the liquid crystal **115** is filled in the region surrounded by the seal is described in this embodiment, the method is not limited to such an example and the seal may be formed on the counter substrate **200** and the liquid crystal **115** may be filled in a region defined by the seal.

Then, the counter substrate **200** is disposed overlapping the TFT substrate **100** in which the liquid crystal **115** is filled and ultra-violet rays are irradiated to the seal portion from a side of the counter-substrate **200** to cure the seal.

Thereafter, the glass substrate adhered to the plastic substrate **201** is removed from the plastic substrate **201** in

the following manner. That is, in the case where the glass substrate is fixed to the plastic substrate **201** by adhesion, the glass substrate is removed from the plastic substrate **201** in such a manner that an end portion of the glass substrate and an end portion of the plastic substrate **201** are made apart from one another in directions opposite to each other, which operation is an operation similar to that could be observed in peeling off the cellophane tape and the seal. On the other hand, in the case where the glass substrate is fixed to the plastic substrate **201** by negative pressure suction, the glass substrate and the plastic substrate **201** are made apart from each other by breaking the negative pressure into an air pressure in a nondestructive manner. Thereafter, the substrate consisting of the TFT substrate **100** and the counter substrate **200** adhered to each other is cut into specific size of substrates and a polarizer **116** for a TFT substrate and a polarizer **216** for a counter substrate are respectively adhered to surfaces of the substrates on sides thereof opposite to opposing surfaces of the substrates, thus completing formation of liquid crystal panel. Note that the glass substrate removed from the plastic substrate in a nondestructive manner is available for re-use after cleaning the surface of the glass substrate. In this case, the adhesive or the like adhered to the glass substrate is removed using an alcohol-based or petroleum-based organic solvent.

As described above, according to the manufacturing steps for completing formation of the counter substrate **200** consisting of the plastic substrate **201**, in the steps ranging from the step for forming the common electrode on the plastic substrate **201** to the step prior to the step for cutting and dividing the counter substrate **200** into the liquid crystal panel units, the glass substrate is adhered to the plastic substrate as a support substrate for the plastic substrate. Accordingly, the bending of plastic substrate adversely affecting steps for manufacturing a liquid crystal panel can be prevented, thereby allowing a plastic substrate to be processed in the same method as that could be employed to process a glass substrate.

The second embodiment of the present invention will be explained with reference to FIGS. **3** and **4**.

Although the polarizer is attached to the plastic substrate after cutting and dividing the substrates into the liquid crystal panels in the first embodiment, the second embodiment describes a method for manufacturing the liquid crystal panel in which a polarization function is previously given to the plastic substrate.

A counter substrate **300** of this embodiment shown in FIG. **3**, which uses a plastic substrate **301** having a polarizer function (hereinafter, referred to as a polarizer-cum-plastic substrate **301**), is assembled to the panel in accordance with a step flow shown in FIG. **4**. An exemplified method will be described in detail below. Note that a method for manufacturing a CF-on-TFT substrate **100** is the same as that of the first embodiment and therefore, the explanation thereof is omitted.

First, a polarizer-cum-plastic substrate **301** having a film thickness of 0.1 to 0.7 mm is fixed to a glass substrate having a plate thickness of 0.4 to 1.1 mm (not shown) by adhesive bonding, negative pressure suction (method for generating negative pressure to suction the plastic substrate) or the like. A thickness of the glass substrate is optionally selected such that an aggregate thickness of the glass and plastic substrates after the polarizer-cum-plastic substrate is attached to the glass substrate does not require a specific modification of manufacturing steps. Furthermore, when the glass substrate and the polarizer-cum-plastic substrate are adhered to each

other, a re-peelable pressure sensitive adhesive (pressure-sensitive adhesive which facilitates peel-off) such as a cellophane tape or a seal selected from a group of materials such as a natural-rubber-based adhesive, an acrylic adhesive, a synthetic-rubber-based adhesive, a silicone-based adhesive is applied to a surface of the glass substrate on a side thereof on which an adhesive should be located by a spin coating, a printing method or the like and, thereafter, the polarizer-cum-plastic substrate **301** is adhered to the glass substrate. Note that silicone or the like may be applied to a surface of the polarizer-cum-plastic substrate **301** on which an adhesive should be located to facilitate peeling off performed in a later step. Furthermore, the glass substrate and the polarizer-cum-plastic substrate **301** are not required to have the same area and the polarizer-cum-plastic substrate **301** may be made slightly larger than the glass substrate to facilitate the peeling off in a later step.

Subsequently, the common electrode **312** made of a transparent metal is formed on the polarizer-cum-plastic substrate **301** by performing a vacuum sputtering or by applying a transparent resist containing ITO particles or the like to the polarizer-cum-plastic substrate **301**. In this case, the heat treatment for transforming the deposited or applied film from the amorphous state to the crystalline state is performed at a temperature of not greater than the heat-resistant temperature of the polarizer-cum-plastic substrate **301** regardless of a state of film, i.e., during and after formation of film.

Subsequently, a method for assembling the TFT substrate **100** and the counter substrate **300** in manufacturing steps of panel is explained.

First, a material made of polyimide or the like for an orientation film is uniformly applied-by printing, coating or the like to predetermined areas to have a predetermined film thickness and, then, baked, the predetermined areas being the surfaces of the TFT substrate **100** and the counter substrate **300** on sides thereof on which a liquid crystal **115** located, in more detail, on which the pixel electrode **112** and the common electrode **312** are located, respectively. In this case, the baking is performed at a temperature of not greater than the heat-resistant temperature of plastic at least with respect to the polarizer-cum-plastic substrate **301**.

Subsequently, to align the liquid crystal **115** in a constant direction, the materials for the orientation films formed on the surfaces of respective substrates are rubbed with a cloth or the like so as to form the orientation films **114** (rubbing treatment).

Thereafter, a seal material of an ultraviolet curing type is drawn on the TFT substrate **100** by a dispenser method and the liquid crystal **115** is filled in a region surrounded by the seal by injecting the liquid crystal **115** using a dropping technique. Although an example in which the seal is formed on the TFT substrate **100** and the liquid crystal **115** is filled in the region surrounded by the seal is described in this embodiment, the method is not limited to such an example and the seal may be formed on the counter substrate **300** and the liquid crystal **115** may be filled in a region defined by the seal.

Then, the counter substrate **300** is disposed overlapping the TFT substrate **100** in which the liquid crystal **115** is filled and ultra-violet rays are irradiated to the seal portion from a side of the counter-substrate **300** to cure the seal.

Thereafter, the glass substrate adhered to the polarizer-cum-plastic substrate **301** is removed from the polarizer-cum-plastic substrate **301** in the following manner. That is, in the case where the glass substrate is fixed to the polarizer-

cum-plastic substrate **301** by adhesion, the glass substrate is removed from the polarizer-cum-plastic substrate **301** in such a manner that an end portion of the glass substrate and an end portion of the polarizer-cum-plastic substrate **301** are made apart from one another in directions opposite to each other, which operation is an operation similar to that could be observed in peeling off the cellophane tape and the seal. On the other hand, in the case where the glass substrate is fixed to the polarizer-cum-plastic substrate **301** by negative pressure suction, the glass substrate and the polarizer-cum-plastic substrate **301** are made apart from each other by breaking the negative pressure into an air pressure in a nondestructive manner. Thereafter, the substrate consisting of the TFT substrate **100** and the counter substrate **300** adhered to each other is cut into specific size of substrates and a polarizer **116** for a TFT substrate and a polarizer **216** for a counter substrate are respectively adhered to surfaces of the substrates on sides thereof opposite to opposing surfaces of the substrates, thus completing formation of liquid crystal panel. Note that the glass substrate removed from the polarizer-cum-plastic substrate in a nondestructive manner is available for re-use after cleaning the surface of the glass substrate. In this case, the adhesive or the like adhered to the glass substrate is removed using an alcohol-based or petroleum-based organic solvent.

Also in this embodiment, the bending of polarizer-cum-plastic substrate adversely affecting steps for manufacturing a liquid crystal panel can be prevented, thereby allowing a polarizer-cum-plastic substrate to be processed in the same manner as that could be employed to process a glass substrate.

As has been described heretofore, according to the method for manufacturing a liquid crystal display device of the present invention, the TFT and the color filter are formed on the glass substrate in the active-matrix substrate and the common electrode is formed on the polarizer-cum-plastic substrate in the counter substrate that employs a polarizer-cum-plastic substrate as a substrate. In this case, according to the manufacturing steps for completing formation of the counter electrode using the polarizer-cum-plastic substrate as a counter substrate of a liquid crystal panel, in the steps ranging from the step for forming the common electrode on the polarizer-cum-plastic substrate to the step prior to the step for cutting and dividing the counter substrate **200** into the liquid crystal panel units, the glass substrate is adhered to the polarizer-cum-plastic substrate as a support substrate for the polarizer-cum-plastic substrate. Accordingly, the bending of polarizer-cum-plastic substrate adversely affecting steps for manufacturing a liquid crystal panel can be prevented, thereby allowing a polarizer-cum-plastic substrate to be processed in the same manner as that could be employed to process a glass substrate.

What is claimed is:

1. A method for manufacturing a liquid crystal display device, comprising:

- a step for disposing a TFT substrate and a counter substrate facing said TFT substrate apart a predetermined distance from each other; and
- a step for filling a space between said TFT substrate and said counter substrate with a liquid crystal,

said liquid crystal display device being constructed such that at least one of said TFT substrate and said counter substrate consists of a plastic substrate, said method further being constructed such that said method comprises a substrate separation step for cutting and dividing a combined substrate consisting of said TFT sub-

strate and said counter substrate, both substrates interposing said liquid crystal therebetween, into substrate units, and one of surfaces of said plastic substrate is supported by a support substrate until said combined substrate is cut and divided.

2. The method for manufacturing a liquid crystal display device according to claim 1, wherein a method for manufacturing said TFT substrate comprises:

- a step for forming a thin film transistor and a wiring on a first substrate;
 - a step for depositing a protective film covering said thin film transistor and said wiring on said first substrate;
 - a step for forming a color layer corresponding to said thin film transistor and a black matrix shielding light from being irradiated onto said thin film transistor on said protective film;
 - a step for depositing a flattening film covering said color layer and said black matrix on said protective film;
 - a step for opening a part of said protective film and said flattening film to form a contact hole reaching a source electrode of said thin film transistor in said protective film and said flattening film;
 - a step for forming a transparent pixel electrode covering said contact holes and connected to said source electrode on said the flattening film;
 - a step for forming a spacer on said flattening film;
 - a step for forming an orientation film covering said transparent pixel electrode and said spacer on said flattening film, and subsequently, rubbing said orientation film;
 - a step for forming a seal material to surround a predetermined region on said orientation film; and
 - a step for dropping a liquid crystal into said region surrounded by said seal material constituting said orientation film, and
- a method for manufacturing said counter substrate comprises:
- a step for covering a second substrate with a transparent electrode and adhering a support substrate to a surface of said second substrate, said surface being located on a side of said second substrate opposite to said transparent electrode; and
 - a step for forming a material for an orientation film on said transparent electrode, and sequentially, rubbing said orientation film, and
- said method for manufacturing a liquid crystal display device further comprising:
- a step for disposing said TFT substrate and said counter substrate overlapping each other such that said orientation films of said TFT substrate and said counter substrate face each other, and then, making said orientation film of said counter substrate contact said spacer and said seal material of said TFT substrate;
 - a step for curing said seal material to make said TFT substrate and said counter substrate adhere to each other, thereby forming a semi-completed panel;
 - a step for removing said second substrate from said support substrate,
 - a step for cutting and dividing said semi-completed panel into panel units; and
 - a step for attaching a polarizer to a surface of at least said first substrate out of said first and second substrates constituting said panel unit, said surface being located opposite to said liquid crystal, and

11

said support substrate being previously attached to a surface of said second substrate, said surface being located opposite to said transparent electrode, before said step for forming said transparent electrode on said second substrate.

3. The method for manufacturing a liquid crystal display device according to the claim 1, wherein said second substrate is formed of a plastic substrate.

4. The method for manufacturing a liquid crystal display device according to the claim 2, wherein another polarizer is attached to a surface of said second substrate, said surface of said second substrate being located opposite to said liquid crystal, in said step for attaching a polarizer to a surface of at least said first substrate out of said first and second

12

substrates constituting said panel unit, said surface of at least said first substrate being located opposite to said liquid crystal.

5. The method for manufacturing a liquid crystal display device according to the claim 2, wherein said polarizer is attached only to said surface of said first substrate in said step for attaching a polarizer to a surface of at least said first substrate out of said first and second substrates constituting said panel unit, said surface of at least said first substrate being located opposite to said liquid crystal, and said second substrate is formed of a polarizer-cum-plastic substrate.

6. The method for manufacturing a liquid crystal display device according to the claim 2, wherein said support substrate is formed of a glass substrate.

* * * * *

| | | | |
|-------------|---|-----------------------|------------|
| 专利名称(译) | 液晶显示装置的制造方法 | | |
| 公开(公告)号 | US6566154 | 公开(公告)日 | 2003-05-20 |
| 申请号 | US10/160071 | 申请日 | 2002-06-04 |
| 申请(专利权)人(译) | NEC公司 | | |
| [标]发明人 | YAMAMOTO YUJI | | |
| 发明人 | YAMAMOTO, YUJI | | |
| IPC分类号 | G02F1/1333 G02F1/13 H01L27/12 H01L21/70 H01L21/84 H01L21/336 H01L21/77 H01L29/786 H01L21/00 | | |
| CPC分类号 | G02F1/133351 H01L27/1266 H01L27/1214 G02F1/133305 G02F2001/13415 | | |
| 代理机构(译) | YOUNG & THOMPSON | | |
| 优先权 | 2001168009 2001-06-04 JP | | |
| 其他公开文献 | US20020182766A1 | | |
| 外部链接 | Espacenet | USPTO | |

摘要(译)

塑料衬底用作对衬底，其构成液晶面板的两个衬底之一。为了形成这样的液晶面板，由塑料基板构成的对置基板在玻璃基板作为塑料基板的支撑基板粘附到塑料基板的情况下制造，其步骤范围从形成共用的步骤开始。在塑料基板上的电极到步骤之前的步骤，用于将对置基板切割并分割成液晶面板单元。因此，塑料基板可以用与加工玻璃基板相同的方法加工。

