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(54) **LIQUID CRYSTAL DISPLAY DEVICE INCLUDING LIQUID CRYSTAL CAPSULE AND METHOD OF FABRICATING THE SAME**

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(57) **ABSTRACT**

A liquid crystal display device includes: a substrate having first, second and third sub-pixels; a thin film transistor in each of the first, second and third sub-pixels on a front surface of the substrate; a pixel electrode and a common electrode in each of the first, second and third sub-pixels on the substrate, the pixel electrode and the common electrode spaced apart from each other; a liquid crystal layer on the pixel electrode and the common electrode, the liquid crystal layer including a liquid crystal capsule and a binder; an auxiliary adhesive layer on the liquid crystal layer; an optical film on the auxiliary adhesive layer; a first adhesive layer and a first polarizing plate sequentially on a rear surface of the substrate; and a second adhesive layer and a second polarizing plate sequentially on the optical film.

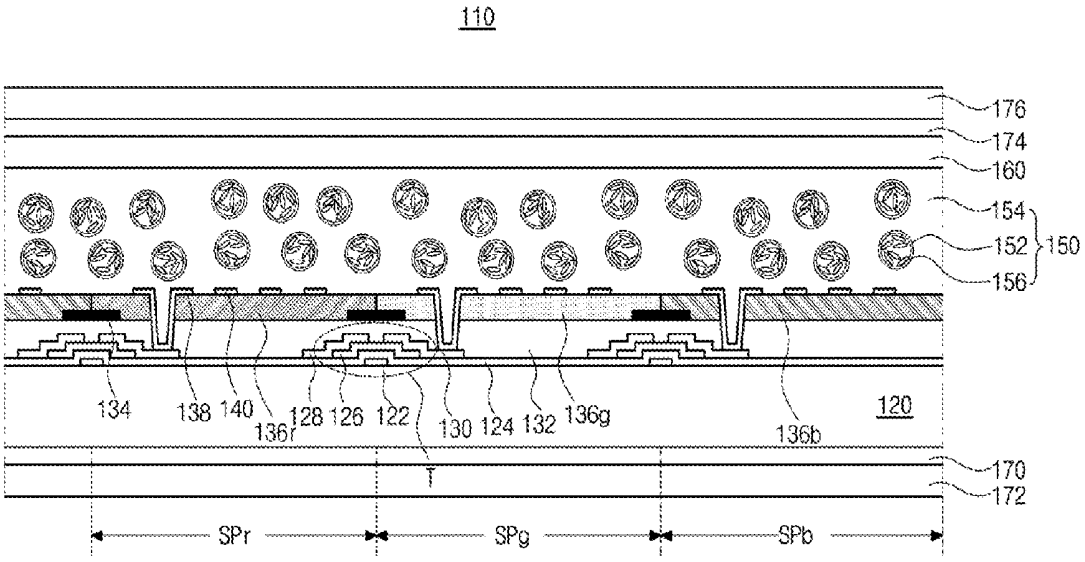

FIG. 1A
Related Art

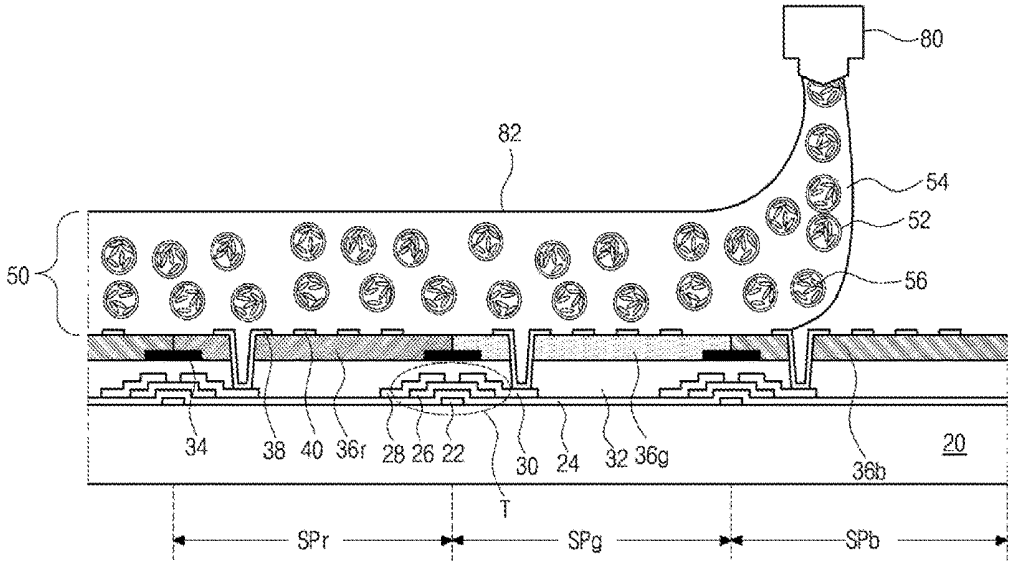

FIG. 1B
Related Art

10

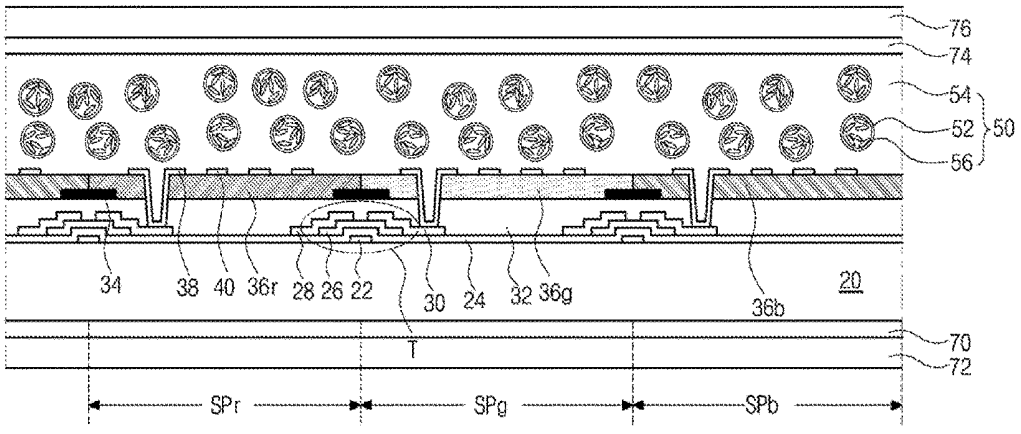

FIG. 2
Related Art

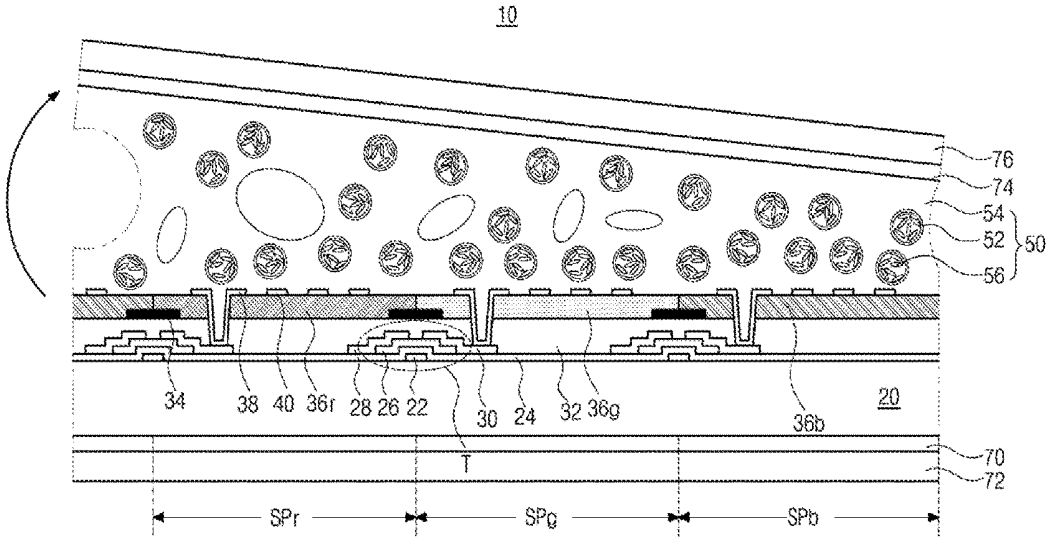

FIG. 3

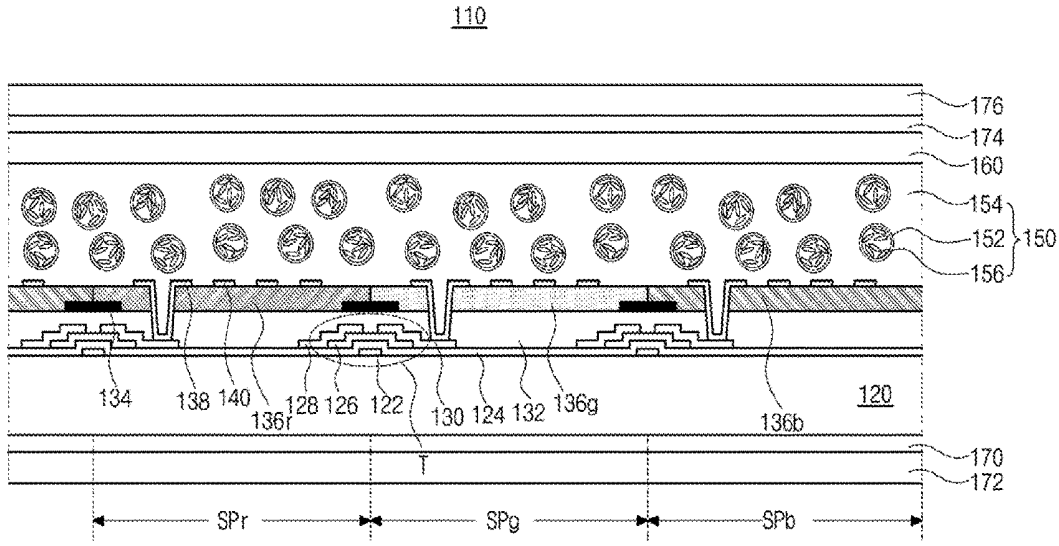

FIG. 4

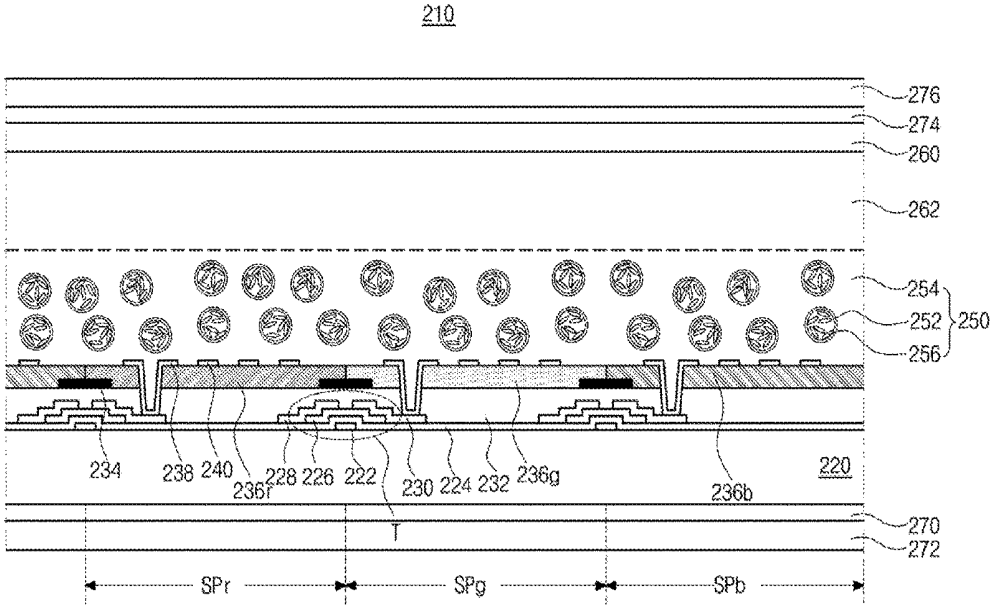
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FIG. 5A

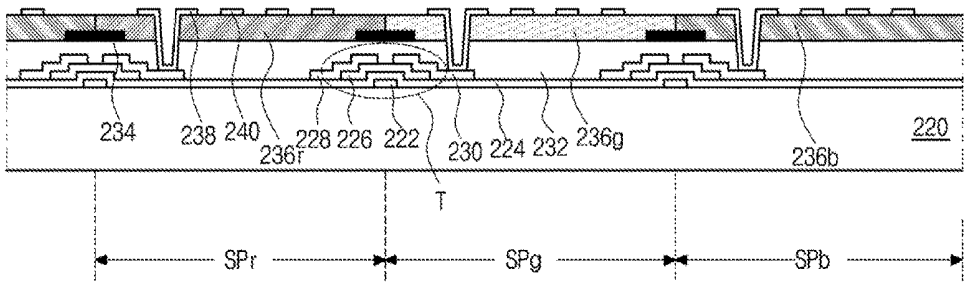
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FIG. 5B

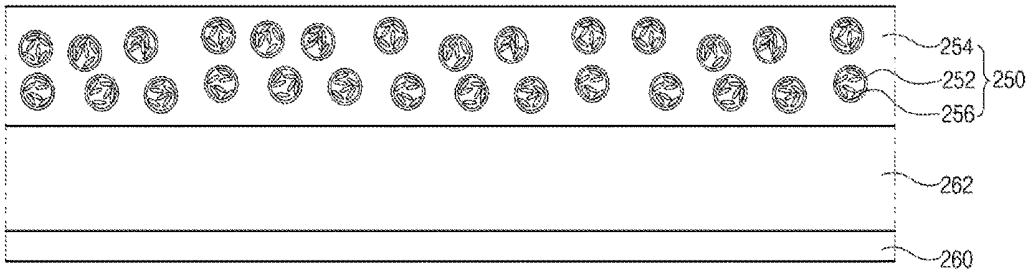
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FIG. 5C

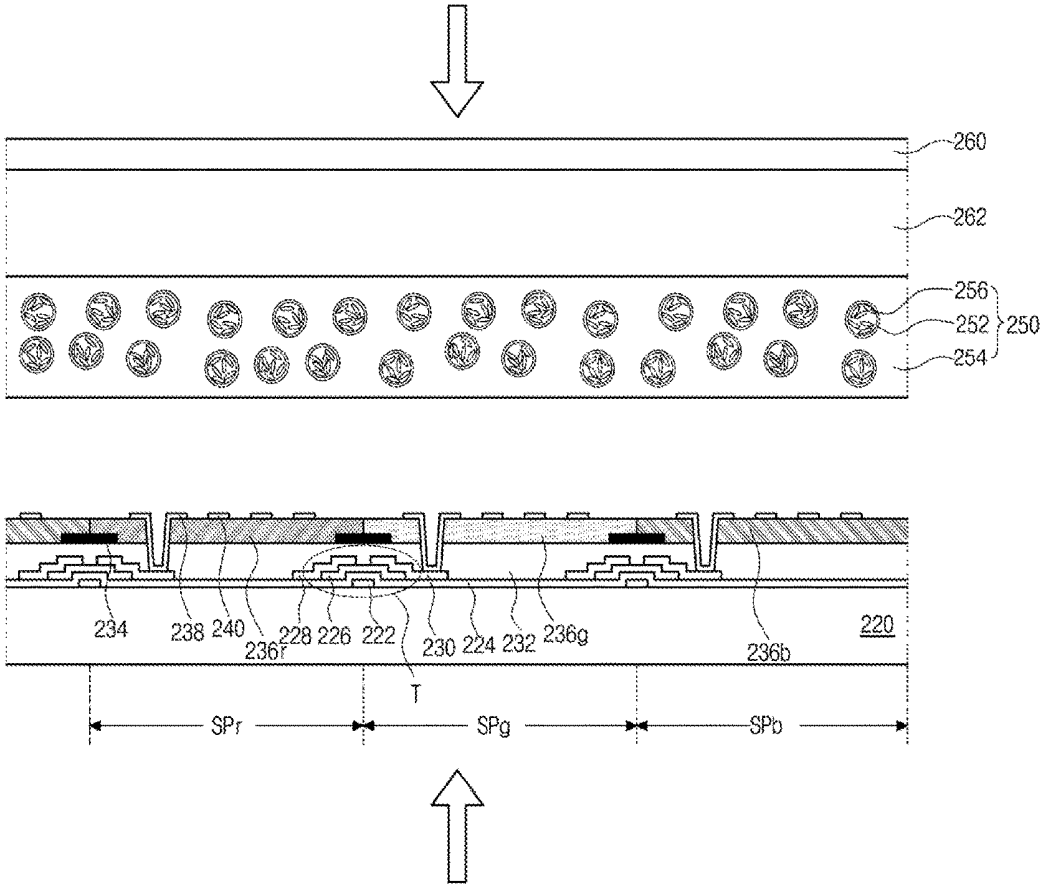
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FIG. 5D

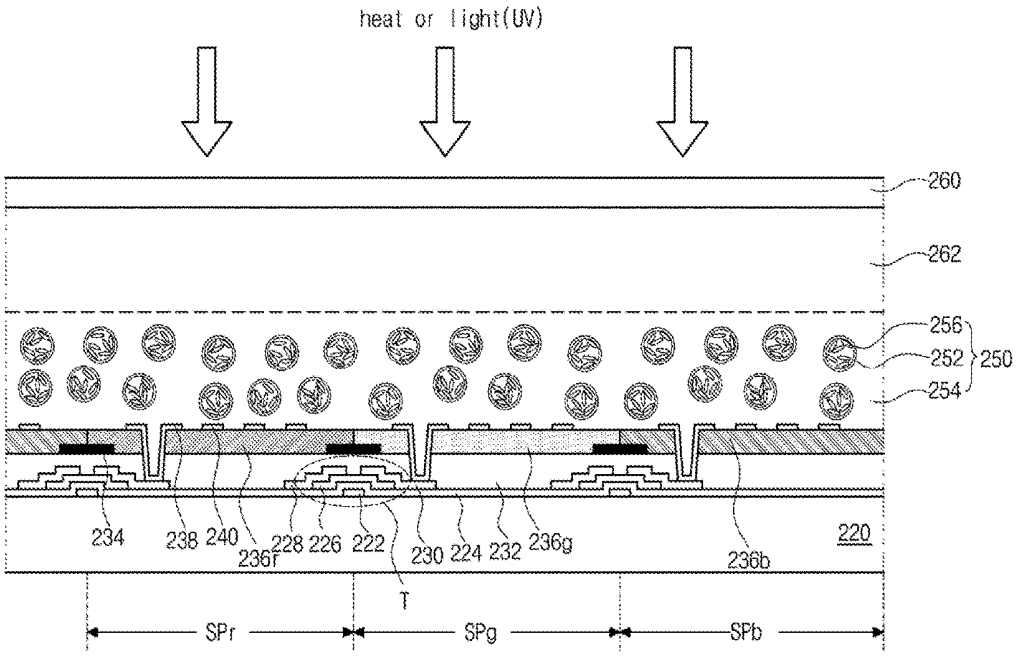
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FIG. 5E

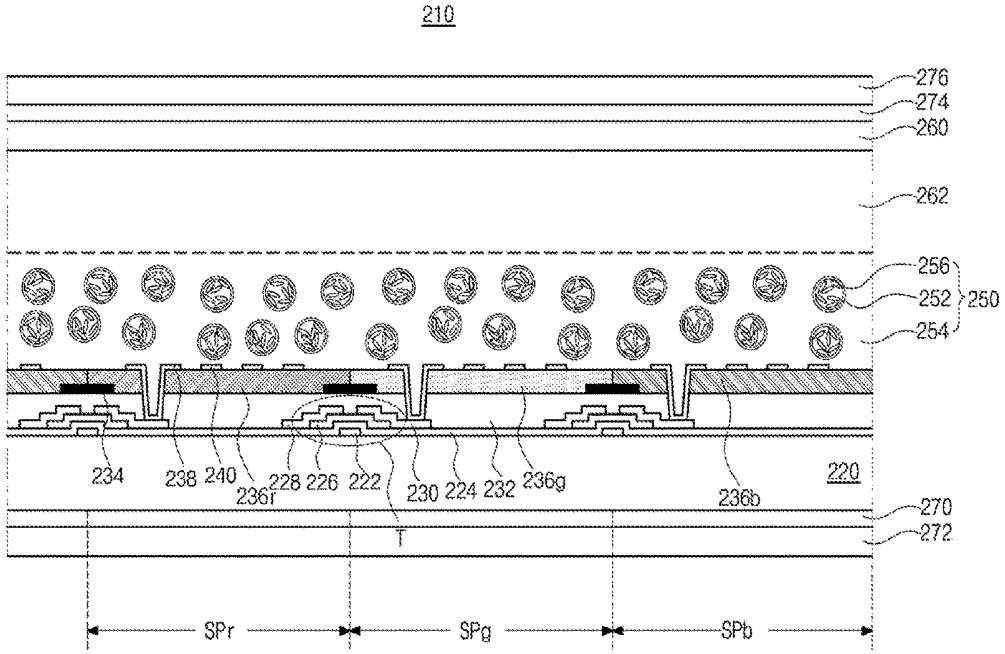
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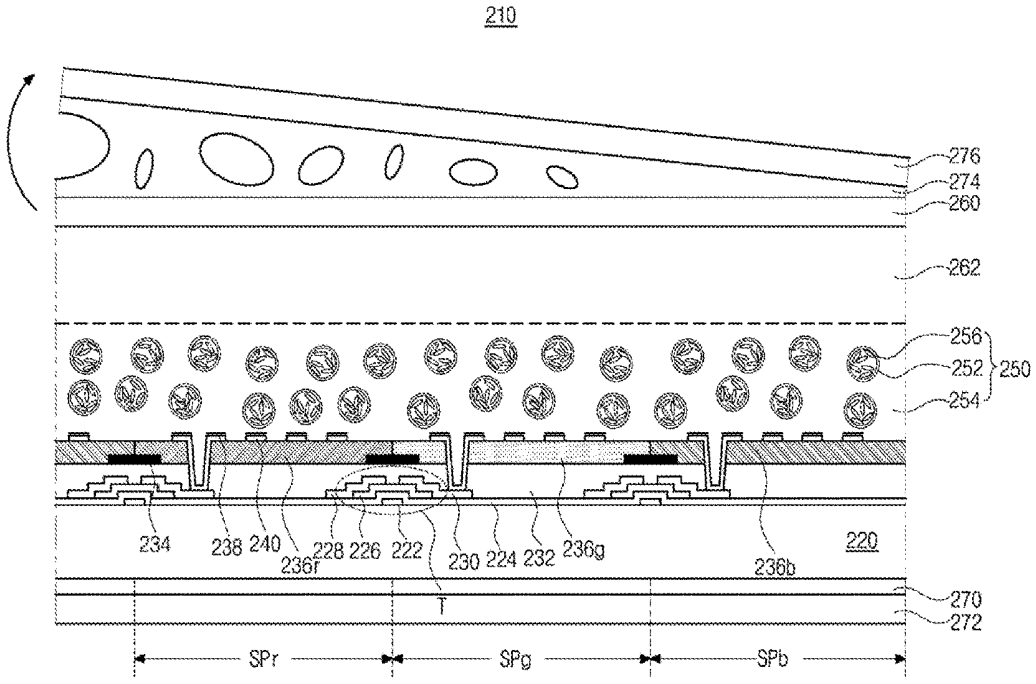
FIG. 6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LIQUID CRYSTAL DISPLAY DEVICE INCLUDING LIQUID CRYSTAL CAPSULE AND METHOD OF FABRICATING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority of Korean Patent Application No. 10-2017-0155011, filed in the Republic of Korea on Nov. 20, 2017, which is hereby incorporated by reference in its entirety for all purposes as if fully set forth herein.

BACKGROUND

Field of the Disclosure

[0002] The present disclosure relates to a liquid crystal display device, and more particularly, to a liquid crystal display device where a generation of a bubble is prevented and a rework is improved by attaching an array substrate having a thin film transistor and an optical film having an auxiliary adhesive layer and a liquid crystal layer and a method of fabricating the same.

Description of the Background

[0003] Recently, as the information age progresses, display devices processing and displaying a large amount of information have rapidly advanced. For example, various flat panel displays (FPDs) having a thin profile, a light weight and a low power consumption have been researched.

[0004] As a result, a thin film transistor liquid crystal display (TFT-LCD) device having an excellent color reproducibility and a thin profile has been developed. The LCD device displays an image using an optical anisotropy and a polarization property of a liquid crystal molecule.

[0005] In general, the LCD device includes first and second substrates facing and spaced apart from each other and a liquid crystal layer between the first and second substrates. Since the LCD device includes two glass substrates, the LCD device has a relatively heavy weight and is relatively bulky and it is not easy to apply the LCD device to a flexible display device.

[0006] To improve the above disadvantages of the LCD device, an LCD device including a liquid crystal capsule where a liquid crystal layer including a plurality of liquid crystal capsules is formed on a substrate through a coating method has been suggested. The LCD device including a liquid crystal capsule displays a gray level by changing an effective refractive index anisotropy (or an average refractive index anisotropy) according to an electric field.

[0007] FIGS. **1**A and **1**B are cross-sectional views showing a method of fabricating a liquid crystal display device including a liquid crystal capsule according to the related art.

[0008] In FIG. **1**A, a substrate **20** includes red, green and blue sub-pixels SPr, SPg and SPb, and a thin film transistor (TFT) T, a pixel electrode **38** and a common electrode **40** are formed in each of the red, green and blue sub-pixels SPr, SPg and SPb on the substrate **20**.

[0009] A gate electrode **22** is formed in each of the red, green and blue sub-pixels SPr, SPg and SPb on the substrate **20**, and a gate insulating layer **24** is formed on the gate electrode **22** in a whole of the substrate **20**.

[0010] A semiconductor layer **26** is formed on the gate insulating layer **24** corresponding to the gate electrode **22**, and a source electrode **28** and a drain electrode **30** are formed on both end portions of the semiconductor layer **26**.

[0011] The gate electrode **22**, the semiconductor layer **26**, the source electrode **28** and the drain electrode **30** constitute the TFT T.

[0012] A passivation layer **32** is formed on the TFT T in a whole of the substrate **20**, and a black matrix **34** is formed at a boundary portion of the red, green and blue sub-pixels SPr, SPg and SPb on the passivation layer **32**.

[0013] Red, green and blue color filters **36***r*, **36***g* and **36***b* are formed in the red, green and blue sub-pixels SPr, SPg and SPb, respectively, on the black matrix **34**. The red, green and blue color filters **36***r*, **36***g* and **36***b* constitute a color filter layer.

[0014] A pixel electrode **38** and a common electrode **40** are formed in each of the red, green and blue sub-pixels SPr, SPg and SPb on the color filter layer. The pixel electrode **38** is connected to the drain electrode **30** of the TFT T, and the common electrode **40** is spaced apart from the pixel electrode **38**.

[0015] In addition, after a liquid crystal capsule material layer **82** is formed on the substrate **20** having the TFT T, the pixel electrode **38** and the common electrode **40** by coating a liquid crystal capsule solution including a liquid crystal capsule **52** and a binder **54** through a nozzle **80**, the liquid crystal capsule material layer **82** are dried or cured to form a liquid crystal layer **50** including the liquid crystal capsule **52** on the substrate **20**.

[0016] In FIG. **1**B, a liquid crystal display (LCD) device **10** including a liquid crystal capsule according to the related art is completed by sequentially forming a first adhesive layer **70** and a first polarizing plate **72** under the substrate **20** and sequentially forming a second adhesive layer **74** and a second polarizing plate **76** on the liquid crystal layer **50**.

[0017] In the LCD device **10** including a liquid crystal capsule, since the second adhesive layer **74** is directly formed on the liquid crystal layer **50**, the liquid crystal layer **50** may be deteriorated by an adhesive material of the second adhesive layer **74**.

[0018] For example, a distribution of the liquid crystal capsule **52** of an upper portion of the liquid crystal layer **50** may become non-uniform due to diffusion of the adhesive material of the second adhesive layer **74** to the upper portion of the liquid crystal layer **50**.

[0019] In addition, an adjustment of a concentration of a solid in the liquid crystal capsule solution is required to apply the liquid crystal layer **50** including the liquid crystal capsule **52** to the LCD device **10** using the substrate **20** of the other kind. However, a condition such as the concentration of the solid may not be easily changed and a thickness of the liquid crystal layer **50** may not be easily maintained.

[0020] Further, when the second polarizing plate **76** is attached to the liquid crystal layer **50** through the second adhesive layer **74**, an absorption axis of the second polarizing plate **76** may be misaligned. When the absorption axis of the second polarizing plate **76** is misaligned, the second polarizing plate **76** is removed and then a rework of attaching the second polarizing plate **76** is required. However, the liquid crystal layer **50** may be deteriorated during the rework.

[0021] FIG. **2** is a cross-sectional view showing a rework of a liquid crystal display device including a liquid crystal

capsule according to the related art. Reference is made to FIGS. **1**A and **1**B with FIG. **2**.

[0022] In FIG. **2**, when the second polarizing plate **76** attached to the liquid crystal layer **50** through the second adhesive layer **74** is misaligned, the misaligned second polarizing plate **76** is removed from the substrate **20** including the liquid crystal layer **50** and then the new second polarizing plate **76** is attached to a top surface of the liquid crystal layer **50** again.

[0023] However, since a viscosity of the liquid crystal layer including the liquid crystal capsule **52** is similar to a viscosity of the second adhesive layer **74**, the second adhesive layer **74** and the second polarizing plate **76** may not be removed and the liquid crystal layer **50** may be removed or deteriorated during the rework of removing the second polarizing plate **76** from the substrate **20** including the liquid crystal layer **50**. As a result, the rework becomes impossible and a fabrication cost inevitably increases.

SUMMARY

[0024] Accordingly, aspects of the present disclosure are directed to a liquid crystal display device including a liquid crystal capsule and a method of fabricating the same that substantially obviate one or more of the problems due to limitations and disadvantages of the related art.

[0025] Aspects of the present disclosure relate to a liquid crystal display device including a liquid crystal capsule where deterioration of a liquid crystal layer and remaining of a bubble are prevented and a fabrication cost is reduced.

[0026] Additional features and aspects will be set forth in the description that follows, and in part will be apparent from the description, or may be learned by practice of the inventive concepts provided herein. Other features and aspects of the inventive concepts may be realized and attained by the structure particularly pointed out in the written description, or derivable therefrom, and the claims hereof as well as the appended drawings.

[0027] To achieve these and other aspects of the inventive concepts, as embodied and broadly described, a liquid crystal display device includes: a substrate having first, second and third sub-pixels; a thin film transistor in each of the first, second and third sub-pixels on a front surface of the substrate; a pixel electrode and a common electrode in each of the first, second and third sub-pixels on the substrate, the pixel electrode and the common electrode spaced apart from each other; a liquid crystal layer on the pixel electrode and the common electrode, the liquid crystal layer including a liquid crystal capsule and a binder; an auxiliary adhesive layer on the liquid crystal layer; an optical film on the auxiliary adhesive layer; a first adhesive layer and a first polarizing plate sequentially on a rear surface of the substrate; and a second adhesive layer and a second polarizing plate sequentially on the optical film.

[0028] In another aspect, a method of fabricating a liquid crystal display device includes: forming a thin film transistor, a pixel electrode and a common electrode in each of first, second and third sub-pixels on a front surface of a substrate, the pixel electrode and the common electrode spaced apart from each other; sequentially forming an auxiliary adhesive layer and a liquid crystal layer on an optical film; attaching the substrate and the optical film such that the pixel electrode and the common electrode contact the liquid crystal layer; and sequentially forming a first adhesive layer and a first polarizing plate on a rear surface of the substrate and sequentially forming a second adhesive layer and a second polarizing plate on the optical film.

[0029] It is to be understood that both the foregoing general description and the following detailed description are explanatory, and are intended to provide further explanation of the aspects as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The accompanying drawings, which are included to provide a further understanding of the disclosure, are incorporated in and constitute a part of this application, illustrate aspects of the disclosure and together with the description serve to explain the principles of the disclosure.

[0031] In the drawings:

[0032] FIGS. **1**A and **1**B are cross-sectional views showing a method of fabricating a liquid crystal display device including a liquid crystal capsule according to the related art;

[0033] FIG. **2** is a cross-sectional view showing a rework of a liquid crystal display device including a liquid crystal capsule according to the related art;

[0034] FIG. **3** is a cross-sectional view showing a liquid crystal display device including a liquid crystal capsule according to a first aspect of the present disclosure;

[0035] FIG. **4** is a cross-sectional view showing a liquid crystal display device including a liquid crystal capsule according to a second aspect of the present disclosure;

[0036] FIGS. **5**A to **5**E are cross-sectional views showing a method of fabricating a liquid crystal display device including a liquid crystal capsule according to a second aspect of the present disclosure; and

[0037] FIG. **6** is a cross-sectional view showing a rework of a liquid crystal display device including a liquid crystal capsule according to a second aspect of the present disclosure.

DETAILED DESCRIPTION

[0038] Reference will now be made in detail to aspects of the present disclosure, examples of which are illustrated in the accompanying drawings. In the following description, when a detailed description of well-known functions or configurations related to this document is determined to unnecessarily cloud a gist of an aspect of the disclosure, the detailed description thereof will be omitted. The progression of processing steps and/or operations described is an example; however, the sequence of steps and/or operations is not limited to that set forth herein and may be changed as is known in the art, with the exception of steps and/or operations necessarily occurring in a certain order. Like reference numerals designate like elements throughout. Names of the respective elements used in the following explanations are selected only for convenience of writing the specification and may be thus different from those used in actual products.

[0039] FIG. **3** is a cross-sectional view showing a liquid crystal display device including a liquid crystal capsule according to a first aspect of the present disclosure.

[0040] In FIG. **3**, a liquid crystal display (LCD) device **110** including a liquid crystal capsule according to a first aspect of the present disclosure includes a substrate **120** and a liquid crystal layer **150** on the substrate **120**.

[0041] The substrate **120** includes first, second and third sub-pixels SPr, SPg and SPb. The first, second and third

sub-pixels SPr, SPg and SPb may correspond to red, green and blue, respectively or cyan, magenta and yellow, respectively.

[0042] The substrate **120** may include a glass or a flexible material such as plastic.

[0043] A gate electrode **122** is formed in each of the first, second and third sub-pixels SPr, SPg and SPb on the substrate **120**, and a gate insulating layer **124** is formed on the gate electrode **122** including the substrate **120**.

[0044] A semiconductor layer **126** is formed on the gate insulating layer **124** corresponding to the gate electrode **122**, and a source electrode **128** and a drain electrode **130** are disposed on both end portions of the semiconductor layer **126**.

[0045] The gate electrode **122**, the semiconductor layer **126**, the source electrode **128** and the drain electrode **130** constitute a thin film transistor (TFT) T.

[0046] Although not shown, a gate line and a data line are disposed over the substrate **120**. The gate line and the data line cross each other to define the first, second and third sub-pixels SPr, SPg and SPb. The gate electrode **122** of the TFT T may be connected to the gate line and the source electrode **128** of the TFT T may be connected to the data line.

[0047] A passivation layer **132** is disposed on the TFT Tin a whole of the substrate **120**, and a black matrix **134** is disposed at a boundary portion of the first, second and third sub-pixels SPr, SPg and SPb on the passivation layer **132**.

[0048] Red, green and blue color filters **136***r*, **136***g* and **136***b* are disposed in the red, green and blue sub-pixels SPr, SPg and SPb, respectively, on the black matrix **134**. The red, green and blue color filters **136***r*, **136***g* and **136***b* constitute a color filter layer.

[0049] A pixel electrode **138** and a common electrode **140** are disposed in each of the first, second and third sub-pixels SPr, SPg and SPb on the color filter layer. The pixel electrode **138** is connected to the drain electrode **130** of the TFT T through a drain contact hole of the color filter layer and the passivation layer **132**. The common electrode **140** is spaced apart from the pixel electrode **138**.

[0050] Although not shown, each of the pixel electrode **138** and the common electrode **140** may have a bar shape and may include a plurality of bars parallel to and spaced apart from each other in each of the first, second and third sub-pixels SPr, SPg and SPb.

[0051] The liquid crystal layer **150** is formed on the pixel electrode **138** and the common electrode **140** in a whole of the substrate **120**.

[0052] The liquid crystal layer **150** includes a plurality of liquid crystal capsules **152** and a binder **154** where the plurality of liquid crystal capsules **152** is dispersed. Each of the plurality of liquid crystal capsules **152** includes a plurality of liquid crystal molecules **156**, and the binder **154** includes an adhesive material (not shown).

[0053] A thickness of the liquid crystal layer **150** may be changed according to a birefringence property and an optical transmittance of the liquid crystal capsule **152**. For example, the thickness of the liquid crystal layer **150** may be within a range of about 2 μm to about 6 μm.

[0054] The binder **154** disperses the liquid crystal capsule **152** and fixes the liquid crystal layer **150** to the substrate **120**.

[0055] Each of the plurality of liquid crystal capsules **152** is a polymer capsule having a diameter of 1 to 999 nanometers and includes a water soluble material such as poly vinyl alcohol (PVA) or a fat soluble material such as poly methyl methacrylate (PMMA). For example, each of the plurality of liquid crystal capsules **152** may be within a range of about 1 nm to about 320 nm.

[0056] The binder **154** may be transparent or translucent (half-transparent) and may have a water solubility, a fat solubility or a mixed property of a water solubility and a fat solubility. For example, the binder **154** may include a water solubility which has a small influence on the liquid crystal capsule **152**.

[0057] The plurality of liquid crystal molecules **156** may include at least one of a nematic liquid crystal, a ferroelectric liquid crystal and a flexo electric liquid crystal.

[0058] Since the liquid crystal layer **150** including the plurality of liquid crystal capsules **152** and the binder **156** may be formed without an additional orientation layer, the liquid crystal layer **150** may directly contact the pixel electrode **138** and the common electrode **140**.

[0059] An optical film **160** is formed on the liquid crystal layer **150**. The optical film **160** protects the liquid crystal layer **150** including the liquid crystal capsule **152** and may have an optical function.

[0060] For example, the optical film **160** may include one of triacetyl cellulose (TAC) and cyclic olefin copolymer (COC) having an optical isotropy without a retardation.

[0061] In another aspect, the optical film **160** may include a material capable of compensating a birefringence property of the liquid crystal layer **150**.

[0062] A first adhesive layer **170** and a first polarizing plate **172** are sequentially formed under the substrate **120**, and a second adhesive layer **174** and a second polarizing plate **176** are sequentially formed on the liquid crystal layer **150**.

[0063] The LCD device **110** may be fabricated through the following process.

[0064] The TFT T, the color filter layer, the pixel electrode **138** and the common electrode **140** are formed on the substrate **120**. The liquid crystal capsule solution is coated on the optical film **160** and then is dried or cured to form the liquid crystal layer **150**. The LCD device **110** is completed by attaching the substrate **120** having the TFT T, the color filter layer, the pixel electrode **138** and the common electrode **140** and the optical film having the liquid crystal layer **150** and by attaching the first and second polarizing plates **172** and **176** to the substrate **120** and the optical film **160** through the first and second adhesive layers **170** and **174**.

[0065] In the LCD device **110** including the liquid crystal capsule according to the first aspect of the present disclosure, since the optical film **160** on the liquid crystal layer **150** protects the liquid crystal layer **150**, deterioration of the liquid crystal layer **150** due to the adhesive material of the second adhesive layer **174** is prevented.

[0066] In addition, after the liquid crystal capsule solution is formed on the optical film **160**, the optical film **160** is attached to various kinds of substrate **120**. As a result, a condition change of the liquid crystal capsule solution is not required and the thickness of the liquid crystal layer **150** may be kept uniformly.

[0067] In the LCD device **110** including the liquid crystal capsule according to the first aspect of the present disclosure, however, since the liquid crystal layer **150** has a relatively small thickness, a bubble may remain in an interface between the pixel electrode **138** and the liquid

crystal layer **150** and an interface between the common electrode **140** and the liquid crystal layer **150** when the substrate **120** having the TFT T, the color filter layer, the pixel electrode **138** and the common electrode **140** and the optical film having the liquid crystal layer **150** are attached.

[0068] In another aspect, remaining of a bubble may be prevented by forming an auxiliary adhesive layer between the liquid crystal layer and the optical film.

[0069] FIG. **4** is a cross-sectional view showing a liquid crystal display device including a liquid crystal capsule according to a second aspect of the present disclosure.

[0070] In FIG. **4**, a liquid crystal display (LCD) device **210** including a liquid crystal capsule according to a second aspect of the present disclosure includes a substrate **220** and a liquid crystal layer **250** on the substrate **220**.

[0071] The substrate **220** includes first, second and third sub-pixels SPr, SPg and SPb. The first, second and third sub-pixels SPr, SPg and SPb may correspond to red, green and blue, respectively or cyan, magenta and yellow, respectively.

[0072] The substrate **220** may include a glass or a flexible material such as plastic.

[0073] A gate electrode **222** is formed in each of the first, second and third sub-pixels SPr, SPg and SPb on the substrate **220**, and a gate insulating layer **224** is formed on the gate electrode **222** in a whole of the substrate **220**.

[0074] A semiconductor layer **226** is formed on the gate insulating layer **224** corresponding to the gate electrode **222**, and a source electrode **228** and a drain electrode **230** are disposed on both end portions of the semiconductor layer **226**.

[0075] The gate electrode **222**, the semiconductor layer **226**, the source electrode **228** and the drain electrode **230** constitute a thin film transistor (TFT) T.

[0076] Although not shown, a gate line and a data line are disposed over the substrate **220**. The gate line and the data line cross each other to define the first, second and third sub-pixels SPr, SPg and SPb. The gate electrode **222** of the TFT T may be connected to the gate line and the source electrode **228** of the TFT T may be connected to the data line.

[0077] A passivation layer **232** is disposed on the TFT T in a whole of the substrate **220**, and a black matrix **234** is disposed at a boundary portion of the first, second and third sub-pixels SPr, SPg and SPb on the passivation layer **232**.

[0078] Red, green and blue color filters **236***r*, **236***g* and **236***b* are disposed in the red, green and blue sub-pixels SPr, SPg and SPb, respectively, on the black matrix **234**. The red, green and blue color filters **236***r*, **236***g* and **236***b* constitute a color filter layer.

[0079] A pixel electrode **238** and a common electrode **240** are disposed in each of the first, second and third sub-pixels SPr, SPg and SPb on the color filter layer. The pixel electrode **238** is connected to the drain electrode **230** of the TFT T through a drain contact hole of the color filter layer and the passivation layer **232**. The common electrode **240** is spaced apart from the pixel electrode **238**.

[0080] Although not shown, each of the pixel electrode **238** and the common electrode **240** may have a bar shape and may include a plurality of bars parallel to and spaced apart from each other in each of the first, second and third sub-pixels SPr, SPg and SPb.

[0081] The liquid crystal layer **250** is formed on the pixel electrode **238** and the common electrode **240** in a whole of the substrate **220**.

[0082] The liquid crystal layer **250** includes a plurality of liquid crystal capsules **252** and a binder **254** where the plurality of liquid crystal capsules **252** is dispersed. Each of the plurality of liquid crystal capsules **252** includes a plurality of liquid crystal molecules **256**, and the binder **254** includes an adhesive material (not shown).

[0083] A thickness of the liquid crystal layer **250** may be changed according to a birefringence property and an optical transmittance of the liquid crystal capsule **252**. For example, the thickness of the liquid crystal layer **250** may be within a range of about 2 μm to about 6 μm.

[0084] The binder **254** disperses the liquid crystal capsule **252** and fixes the liquid crystal layer **250** to the substrate **220**.

[0085] Each of the plurality of liquid crystal capsules **252** is a polymer capsule having a diameter of 1 to 999 nanometers and includes a water soluble material such as poly vinyl alcohol (PVA) or a fat soluble material such as poly methyl methacrylate (PMMA). For example, each of the plurality of liquid crystal capsules **252** may be within a range of about 1 nm to about 320 nm.

[0086] The binder **254** may be transparent or translucent (half-transparent) and may have a water solubility, a fat solubility or a mixed property of a water solubility and a fat solubility. For example, the binder **254** may include a water solubility which has a small influence on the liquid crystal capsule **252**.

[0087] The plurality of liquid crystal molecules **256** may include at least one of a nematic liquid crystal, a ferroelectric liquid crystal and a flexo electric liquid crystal.

[0088] Since the liquid crystal layer **250** including the plurality of liquid crystal capsules **252** and the binder **256** may be formed without an additional orientation layer, the liquid crystal layer **250** may directly contact the pixel electrode **238** and the common electrode **240**.

[0089] An auxiliary adhesive layer **262** is formed on the liquid crystal layer **250**. The auxiliary adhesive layer **262** may prevent remaining of a bubble when the substrate **220** and an optical film **260** are attached.

[0090] To prevent remaining of a bubble during the step of attaching, a thickness of about 10 μm to about 40 μm is required for the liquid crystal layer **250**. However, the liquid crystal layer **250** of a thickness of about 10 μm to about 40 μm does not have a required birefringence property and a required optical transmittance.

[0091] Accordingly, the auxiliary adhesive layer **262** not including the liquid crystal capsule **252** is formed on the liquid crystal layer **250** for preventing remaining of a bubble. The auxiliary adhesive layer **262** may include a material the same as the adhesive material of the binder **254** of the liquid crystal layer **250** and may have a thickness of about 8 μm to about 34 μm.

[0092] To increase an adhesive force between the liquid crystal layer **250** and the auxiliary adhesive layer **262**, the liquid crystal layer **250** and the auxiliary adhesive layer **262** may further include a reactive additive. The reactive additive may be a material having a reactivity to a heat or a light or a material for compensating a refractive index difference between the liquid crystal layer **250** and the auxiliary adhesive **262**.

[0093] An optical film **260** is formed on the auxiliary adhesive layer **262**. The optical film **260** protects the liquid crystal layer **250** including the liquid crystal capsule **252** and may have an optical function.

[0094] For example, the optical film **260** may include one of triacetyl cellulose (TAC) and cyclic olefin copolymer (COC) having an optical isotropy or a material capable of compensating a birefringence property of the liquid crystal layer **250**.

[0095] A first adhesive layer **270** and a first polarizing plate **272** are sequentially formed under the substrate **220**, and a second adhesive layer **274** and a second polarizing plate **276** are sequentially formed on the liquid crystal layer **250**.

[0096] An adhesive force of the first and second adhesive layers **270** and **274** may be smaller than an adhesive force of the auxiliary adhesive layer **262**.

[0097] The LCD device **210** may be fabricated by attaching the substrate **220** having the TFT T, the color filter layer, the pixel electrode **238** and the common electrode **240** and the optical film **260** having the liquid crystal layer **250**.

[0098] FIGS. **5**A to **5**E are cross-sectional views showing a method of fabricating a liquid crystal display device including a liquid crystal capsule according to a second aspect of the present disclosure. Reference is made to FIG. **4** with FIGS. **5**A to **5**E.

[0099] In FIG. **5**A, the TFT T including the gate electrode **222**, the semiconductor layer **226**, the source electrode **228** and the drain electrode **230** is formed in each of the first, second and third sub-pixels SPr, SPg and SPb on the substrate **220**, and the first, second and third color filters **236***r*, **236***g* and **236***b* are formed in the first, second and third sub-pixels SPr, SPg and SPb, respectively, on the TFT T. The pixel electrode **238** and the common electrode **240** are formed in each of the first, second and third sub-pixels SPr, SPg and SPb, respectively, on the first, second and third color filters **236***r*, **236***g* and **236***b*.

[0100] In FIG. **5**B, the auxiliary adhesive layer **262** of an adhesive material is formed on the optical film **260**. The liquid crystal capsule material layer (not shown) is formed on the auxiliary adhesive layer **262** by coating the liquid crystal capsule solution including the plurality of liquid crystal capsules **252** and the binder **254**, and the liquid crystal capsule material layer is dried or cured to form the liquid crystal layer **250**.

[0101] Each of the plurality of liquid crystal capsules **252** includes the plurality of liquid crystal molecules **256**, and the binder **254** includes the adhesive material (not shown). The adhesive material of the liquid crystal layer **250** may be the same as the adhesive material of the auxiliary adhesive layer **262**.

[0102] For example, the auxiliary adhesive layer **262** may have a thickness of about 8 μm to about 34 μm, and the liquid crystal layer **250** may have a thickness of about 2 μm to about 6 μm.

[0103] In FIG. **5**C, the substrate **220** having the TFT T, the first, second and third color filters **236***r*, **236***g* and **236***b*, the pixel electrode **238** and the common electrode **240** and the optical film **260** having the auxiliary adhesive layer **262** and the liquid crystal layer **250** are attached to each other.

[0104] The adhesive material of the binder **254** of the liquid crystal layer **250** may provide the adhesive force between the substrate **220** and the optical film **260**.

[0105] The auxiliary adhesive layer **262** may prevent remaining of a bubble in an interface between the substrate **220** and the optical film **260** when the substrate **220** and the optical film **260** are attached to each other.

[0106] To prevent remaining of a bubble during the step of attaching, a thickness of about 10 μm to about 40 μm is required for the liquid crystal layer **250**. However, the liquid crystal layer **250** of a thickness of about 10 μm to about 40 μm does not have a required birefringence property and a required optical transmittance.

[0107] Accordingly, instead of forming the liquid crystal layer **250** having a relatively great thickness, the liquid crystal layer **250** is formed to have a normal thickness of about 2 μm to about 6 μm, and the auxiliary adhesive layer **262** of a thickness of about 8 μm to about 34 μm having no liquid crystal capsule **252** is formed between the optical film **260** and the liquid crystal layer **250**, thereby the auxiliary adhesive layer **262** and the liquid crystal layer **250** having a thickness of about 10 μm to about 40 μm. As a result, remaining of a bubble between the optical film **260** and the liquid crystal layer **250** is prevented during the step of attaching.

[0108] In FIG. **5**D, the liquid crystal layer **250** and the auxiliary adhesive layer **262** between the substrate **220** and the optical film attached to each other are cured by using a heat or a light (e.g., ultraviolet (UV) ray).

[0109] Since the adhesive material of the liquid crystal layer **250** and the adhesive material of the auxiliary adhesive layer **262** are cured, the adhesive force of the liquid crystal layer **250** and the auxiliary adhesive layer **262** increases. To further increase the adhesive force, the liquid crystal layer **250** and the auxiliary adhesive layer **262** may further include a reactive additive.

[0110] When the liquid crystal layer **250** and the auxiliary adhesive layer **262** include the same adhesive material, the liquid crystal layer **260** may become similar to the auxiliary adhesive layer **262** except for the liquid crystal capsule **252**. As a result, the interface between the liquid crystal layer **260** and the auxiliary adhesive layer **262** may become blurred.

[0111] In FIG. **5**E, the first polarizing plate **272** is attached to a rear surface of the substrate **220** through the first adhesive layer **270**, and the second polarizing plate **276** is attached to a front surface of the optical film **260** through the second adhesive layer **274**. As a result, the LCD device **210** including the liquid crystal capsule **252** is completed.

[0112] The adhesive force of the auxiliary adhesive layer **262** may be greater than the adhesive force of the first and second adhesive layers **270** and **274** even before the step of curing. After the step of curing, since the adhesive materials of the liquid crystal layer **250** and the auxiliary adhesive layer **262** are cured, the adhesive force of the auxiliary adhesive layer **262** may become further greater than the adhesive force of the first and second adhesive layers **270** and **274**.

[0113] In the LCD device **210** including the liquid crystal capsule according to the second aspect of the present disclosure, since the adhesive force of the auxiliary adhesive layer **262** is greater than the adhesive force of the first and second adhesive layers **270** and **274**, deterioration of the liquid crystal layer **250** during the rework of the second polarizing plate **276** is prevented.

[0114] FIG. **6** is a cross-sectional view showing a rework of a liquid crystal display device including a liquid crystal

capsule according to a second aspect of the present disclosure. Reference is made to FIG. **4** with FIG. **6**.

[0115] In FIG. **6**, when the second polarizing plate **276** attached to the optical film **260** through the second adhesive layer **274** is misaligned, the second polarizing plate **276** is removed from the substrate **220** having the liquid crystal layer **250** and the optical film **260** and then a new second polarizing plate **276** is attached to the optical film **260** again.

[0116] Since the adhesive force of the liquid crystal layer **250** and the auxiliary adhesive layer **262** is further greater than the adhesive force of the second adhesive layer **274** due to the inherent property of the adhesive material and the additional step of curing, the second adhesive layer **274** and the second polarizing plate **276** may be easily removed from the substrate **220** in a state where the liquid crystal layer **250**, the auxiliary adhesive layer **262** and the optical film **260** are attached to the substrate **220**. As a result, the rework is smoothly performed without an error and a fabrication cost is reduced.

[0117] In the LCD device **210** including the liquid crystal capsule according to the second aspect of the present disclosure, since the auxiliary adhesive layer **262** and the optical film **260** on the liquid crystal layer **250** protects the liquid crystal layer **250**, deterioration of the liquid crystal layer **250** due to the adhesive material of the second adhesive layer **274** is prevented and the optical film **260** is applied to various kinds of substrate **220**.

[0118] In addition, after the liquid crystal capsule solution is formed on the optical film **260**, the optical film **260** is attached to various kinds of substrate **220**. As a result, a condition change of the liquid crystal capsule solution is not required and the thickness of the liquid crystal layer **250** may be kept uniformly.

[0119] Further, since the auxiliary adhesive layer **262** is formed between the liquid crystal layer **250** and the optical film **260**, remaining of a bubble is prevented during the step of attaching the substrate **220** and the optical film **260**.

[0120] Moreover, the adhesive force of the liquid crystal layer **250** and the auxiliary adhesive layer **262** is greater than the adhesive force of the second adhesive layer **274**, and the adhesive force of the liquid crystal layer **250** and the auxiliary adhesive layer **262** further increases by the curing. As a result, separation of the liquid crystal layer **250** and the auxiliary adhesive layer **262** from the substrate **220** is prevented during the rework.

[0121] It will be apparent to those skilled in the art that various modifications and variations can be made in the display device of the present disclosure without departing from the technical idea or scope of the disclosure. Thus, it is intended that the present disclosure cover the modifications and variations of this disclosure provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A liquid crystal display device, comprising:

a substrate having first, second and third sub-pixels;

a thin film transistor in each of the first, second and third sub-pixels on a front surface of the substrate;

a pixel electrode and a common electrode in each of the first, second and third sub-pixels on the substrate, the pixel electrode and the common electrode spaced apart from each other;

a liquid crystal layer on the pixel electrode and the common electrode, the liquid crystal layer including a liquid crystal capsule and a binder;

an auxiliary adhesive layer on the liquid crystal layer;

an optical film on the auxiliary adhesive layer;

a first adhesive layer and a first polarizing plate sequentially on a rear surface of the substrate; and

a second adhesive layer and a second polarizing plate sequentially on the optical film.

2. The display device of claim **1**, wherein each of adhesive forces of the liquid crystal layer and the auxiliary adhesive layer is greater than an adhesive force of the second adhesive layer.

3. The display device of claim **1**, wherein the binder includes an adhesive material, and the auxiliary adhesive layer includes a same material as the adhesive material of the binder.

4. The display device of claim **1**, wherein each of the liquid crystal layer and the auxiliary adhesive layer includes a reactive additive having a reactivity to heat or light.

5. The display device of claim **1**, wherein the optical film has an optical isotropy or a compensating property for a birefringence of the liquid crystal layer.

6. A method of fabricating a liquid crystal display device, comprising:

forming a thin film transistor, a pixel electrode and a common electrode in each of first, second and third sub-pixels on a front surface of a substrate, the pixel electrode and the common electrode spaced apart from each other;

sequentially forming an auxiliary adhesive layer and a liquid crystal layer on an optical film;

attaching the substrate and the optical film such that the pixel electrode and the common electrode contact the liquid crystal layer;

sequentially forming a first adhesive layer and a first polarizing plate on a rear surface of the substrate; and

sequentially forming a second adhesive layer and a second polarizing plate on the optical film.

7. The method of claim **6**, wherein each of adhesive forces of the liquid crystal layer and the auxiliary adhesive layer is greater than an adhesive force of the second adhesive layer.

8. The method of claim **6**, further comprising curing the liquid crystal layer and the auxiliary adhesive layer between the substrate and the optical film by using heat or light.

9. The method of claim **6**, wherein the forming the liquid crystal layer on the optical film includes:

forming a liquid crystal capsule material layer on the auxiliary adhesive layer by coating a liquid crystal capsule solution including a liquid crystal capsule and a binder; and

forming the liquid crystal layer by one of drying and curing the liquid crystal capsule material layer.

10. A liquid crystal display device including a thin film transistor substrate where first, second and third sub-pixels are defined, comprising:

a thin film transistor in each of the first, second and third sub-pixels on a front surface of the thin film transistor substrate;

a liquid crystal layer disposed on the thin film transistor, the liquid crystal layer including a liquid crystal capsule and a binder;

an auxiliary adhesive layer on the liquid crystal layer;

an optical film on the auxiliary adhesive layer;

a first adhesive layer and a first polarizing plate sequentially on a rear surface of the thin film transistor substrate; and

a second adhesive layer and a second polarizing plate sequentially on the optical film.

11. The display device of claim **10**, wherein each of adhesive forces of the liquid crystal layer and the auxiliary adhesive layer is greater than an adhesive force of the second adhesive layer.

12. The display device of claim **10**, wherein the binder includes an adhesive material, and the auxiliary adhesive layer includes a same material as the adhesive material of the binder.

13. The display device of claim **10**, wherein each of the liquid crystal layer and the auxiliary adhesive layer includes a reactive additive having a reactivity to heat or light.

14. The display device of claim **10**, wherein the optical film has an optical isotropy or a compensating property for a birefringence of the liquid crystal layer.

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专利名称(译)	液晶显示装置及其制造方法		
公开(公告)号	KR1020190057722A	公开(公告)日	2019-05-29
申请号	KR1020170155011	申请日	2017-11-20
[标]申请(专利权)人(译)	乐金显示有限公司		
申请(专利权)人(译)	LG显示器有限公司		
[标]发明人	이은우 최민근 황정임		
发明人	이은우 최민근 황정임		
IPC分类号	G02F1/1334 G02F1/1335 G02F1/1362 G02F1/137		
CPC分类号	G02F1/1334 G02F1/1335 G02F1/1362 G02F1/137		
外部链接	Espacenet		

摘要(译)

本发明提供一种液晶显示装置，包括：基板，包括第一至第三子像素;薄膜晶体管，设置在基板上的第一至第三子像素中的每一个上，液晶层设置在像素电极和公共电极上，液晶层包括液晶盒和粘合剂;辅助粘合层设置在液晶层上;第一粘合剂层和第一偏振片顺序设置在基板下方，第二粘合剂层和第二偏振器依次设置在光学膜上，提供一种包括胶囊的液晶显示装置。