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(54) **LIQUID CRYSTAL DISPLAY PANEL AND FABRICATING METHOD AND APPARATUS THEREOF**

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(52) **U.S. Cl.** **349/106**; 349/155; 118/300; 118/641

(57) **ABSTRACT**

The disclosed invention is with regard to a liquid crystal display panel including a substrate having a plurality of layers formed thereon, and having a first surface region and a second surface region on a surface of an uppermost layer of the plurality of layers, wherein the first and second surface regions having different surface characteristics in reaction to a particular liquid, and a spacer formed on the second surface region.

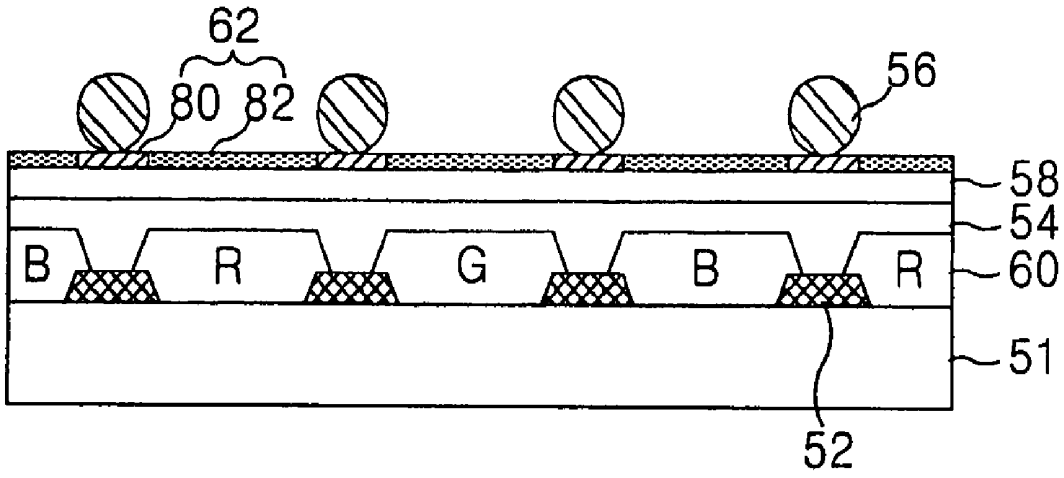


FIG. 1
RELATED ART

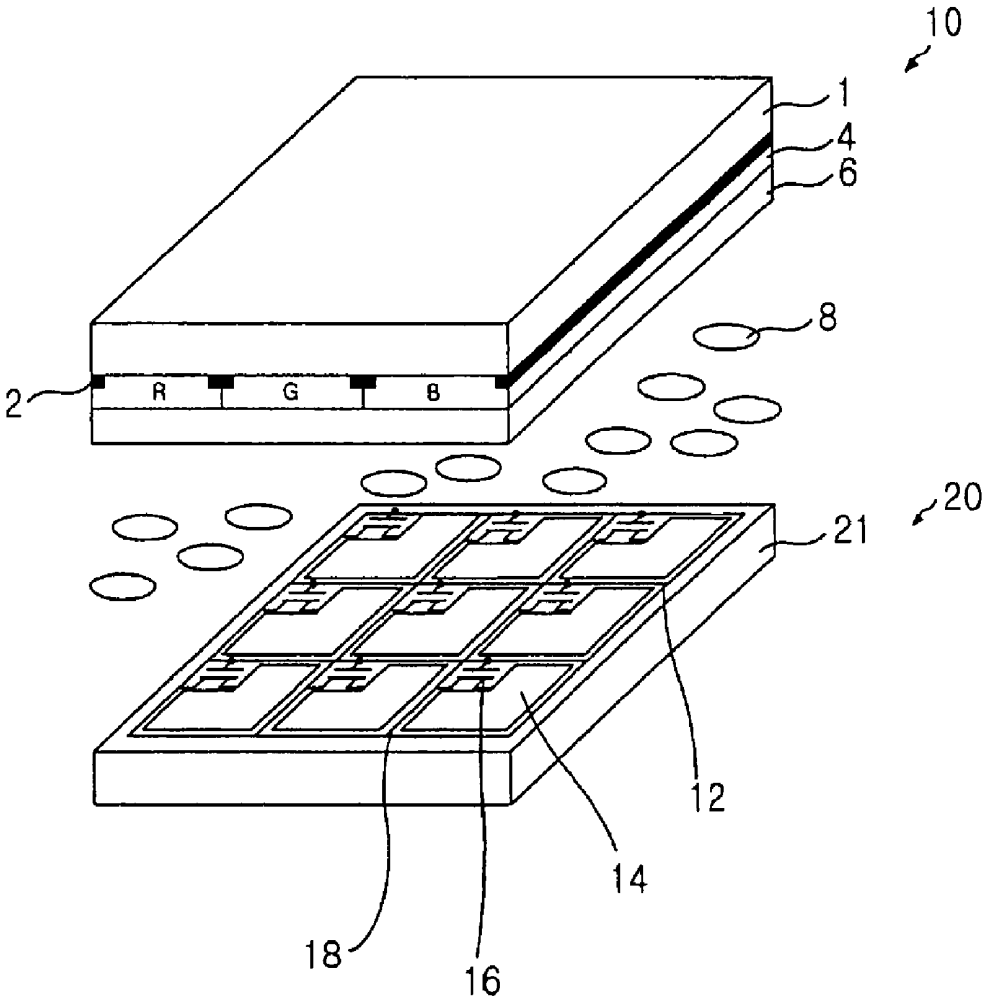


FIG.2A
RELATED ART

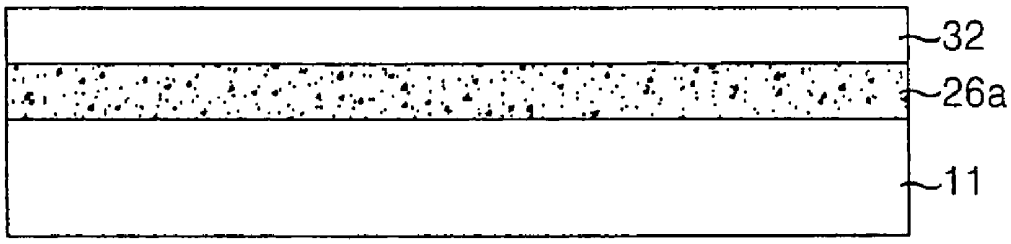


FIG.2B
RELATED ART

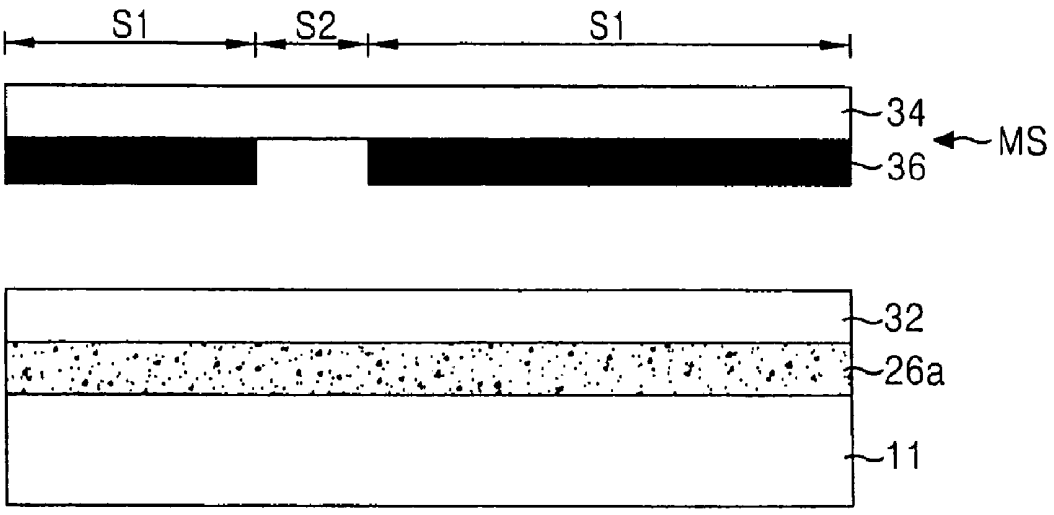


FIG.2C
RELATED ART

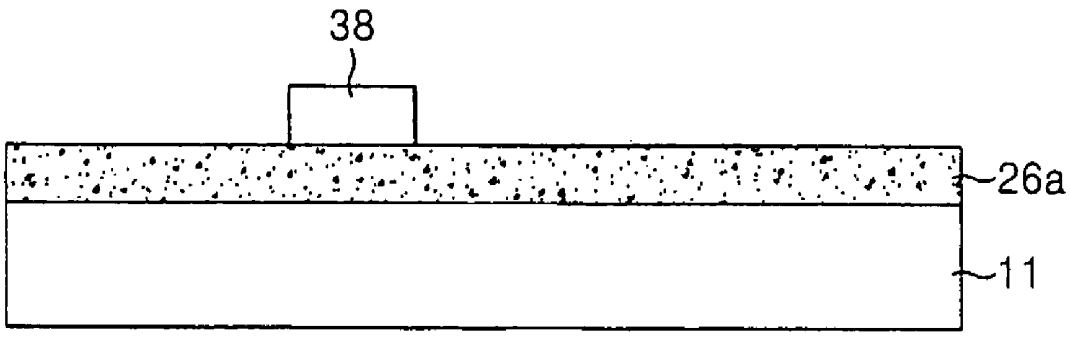


FIG.2D
RELATED ART

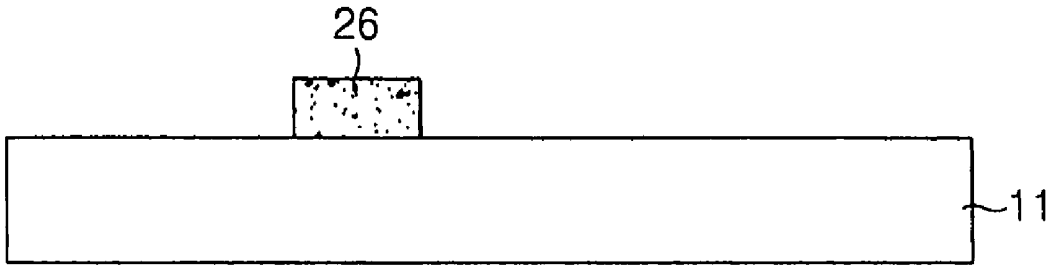


FIG.3A
RELATED ART

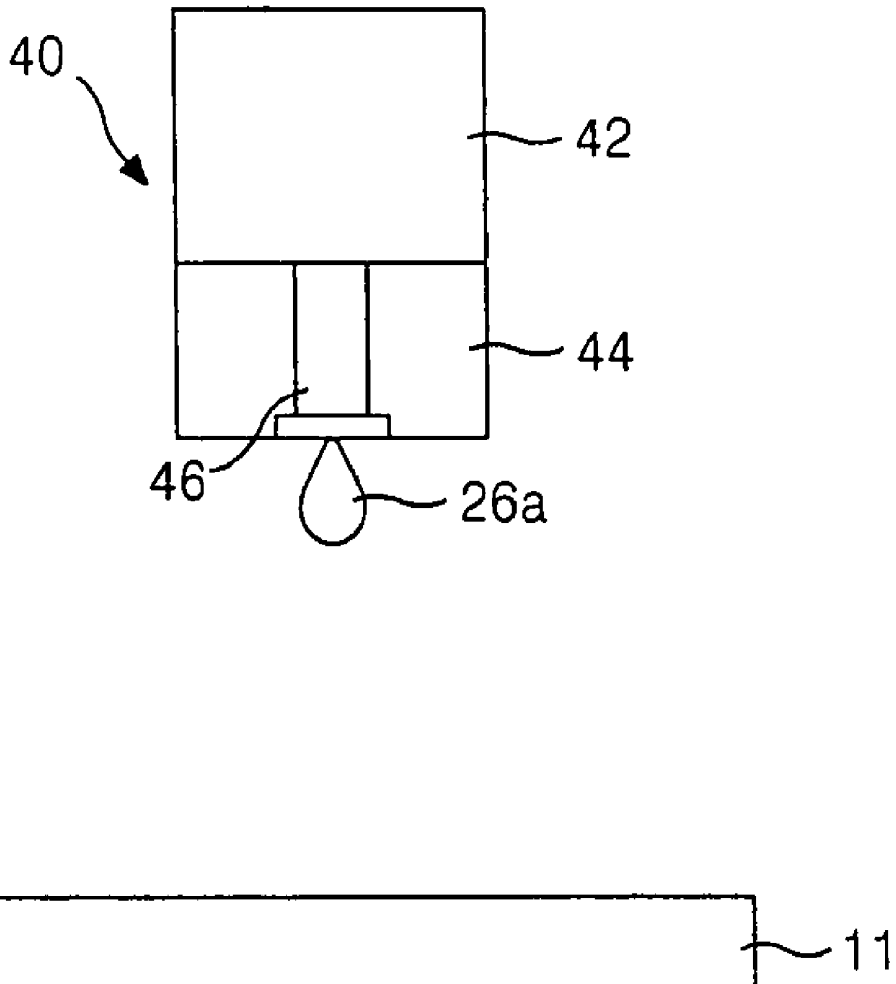
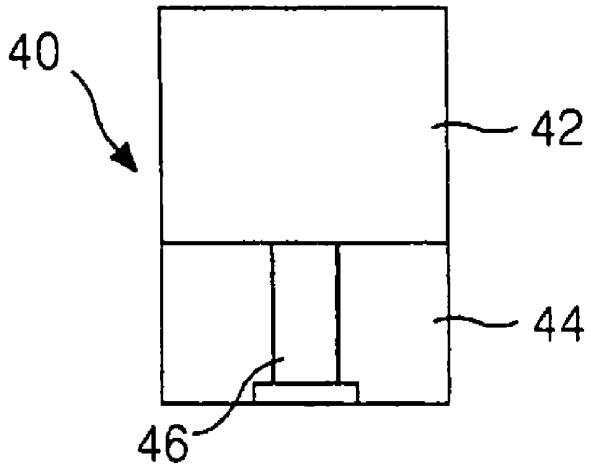


FIG.3B
RELATED ART



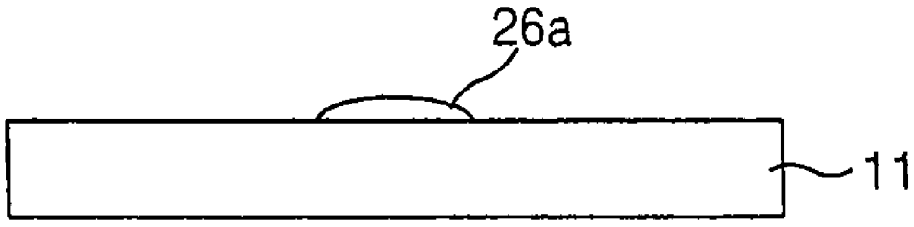


FIG.3C
RELATED ART

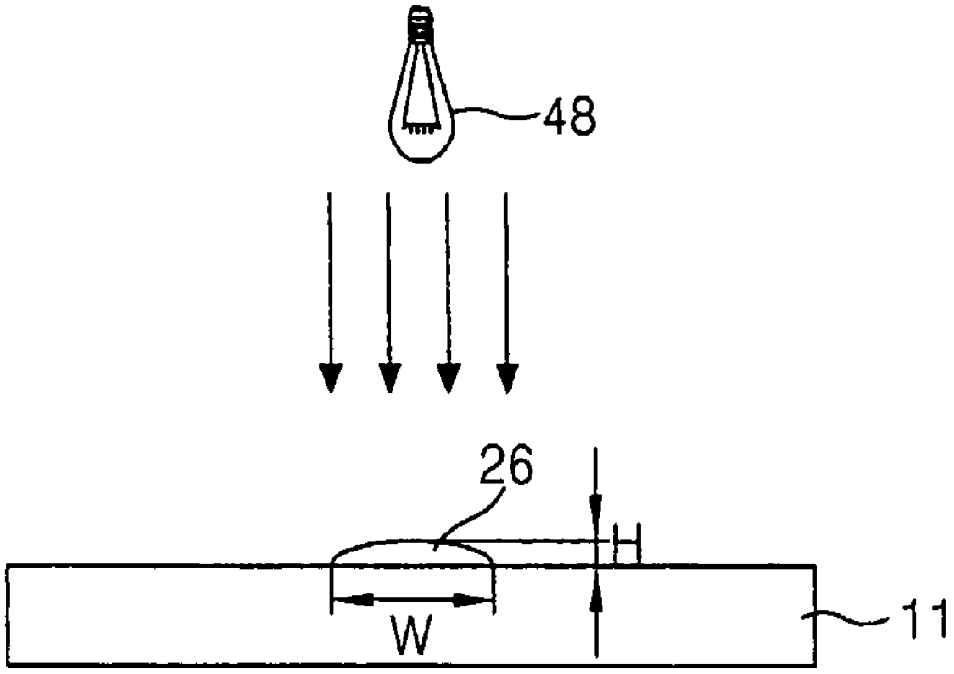


FIG. 4

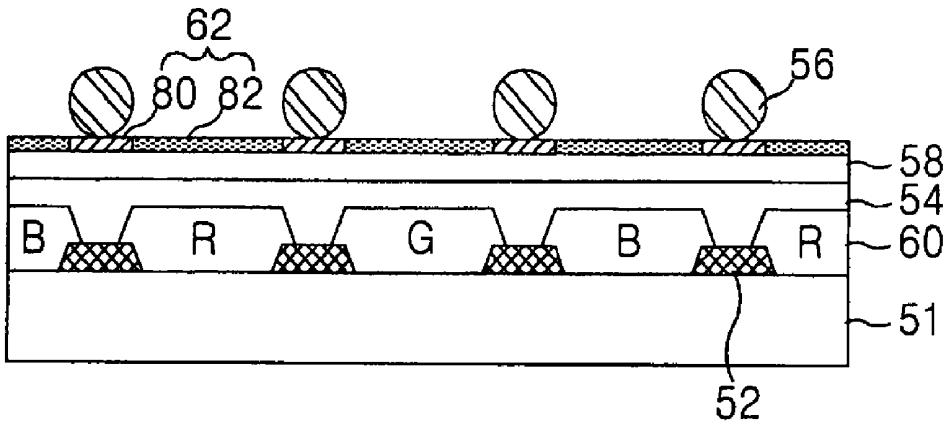


FIG.5

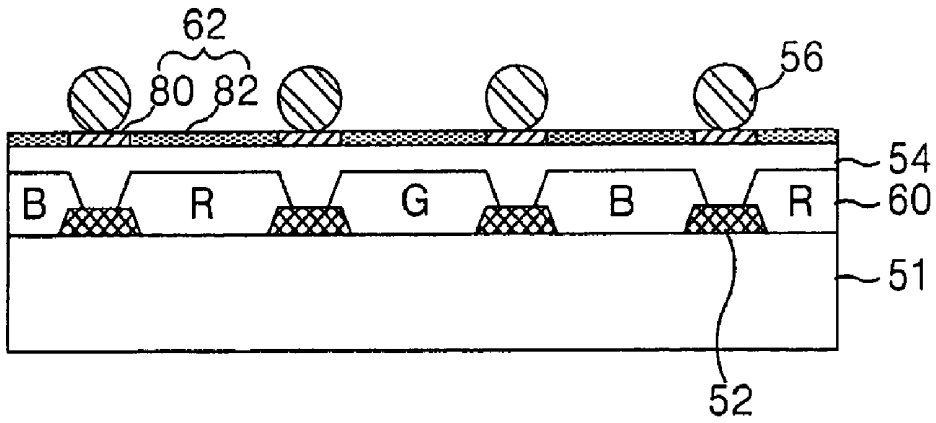


FIG.6A

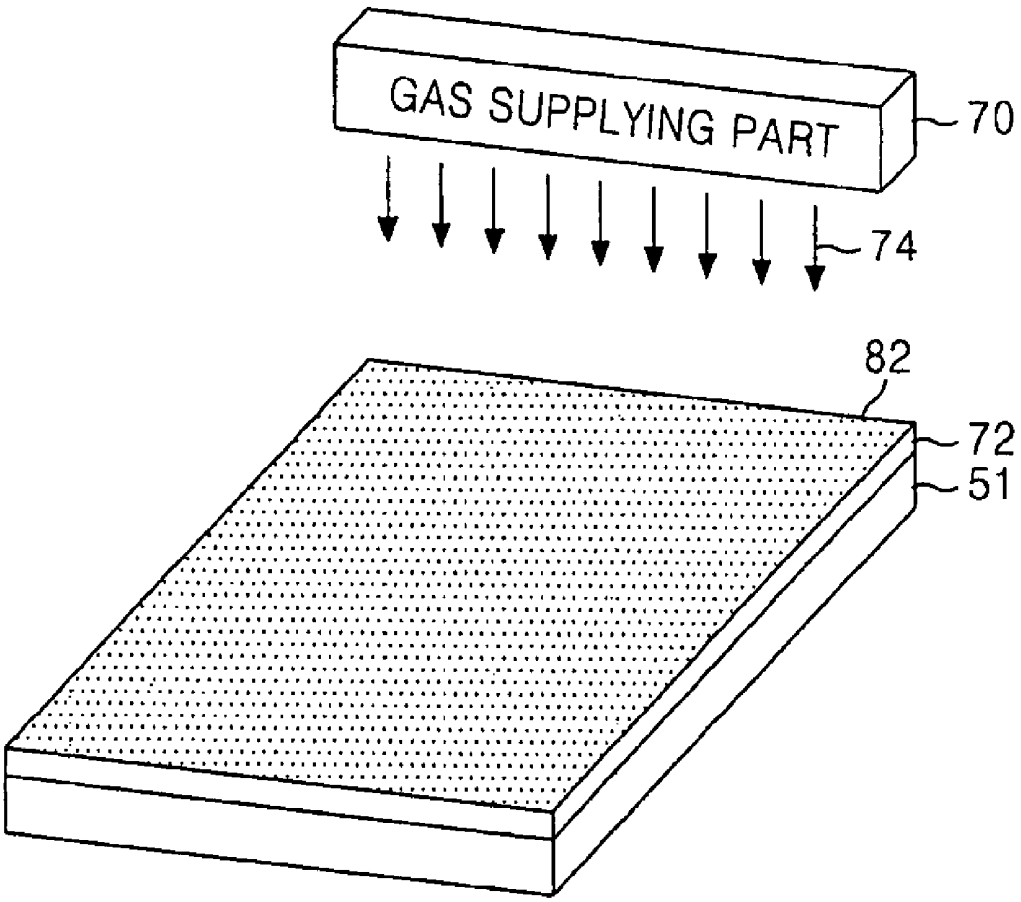


FIG.6B

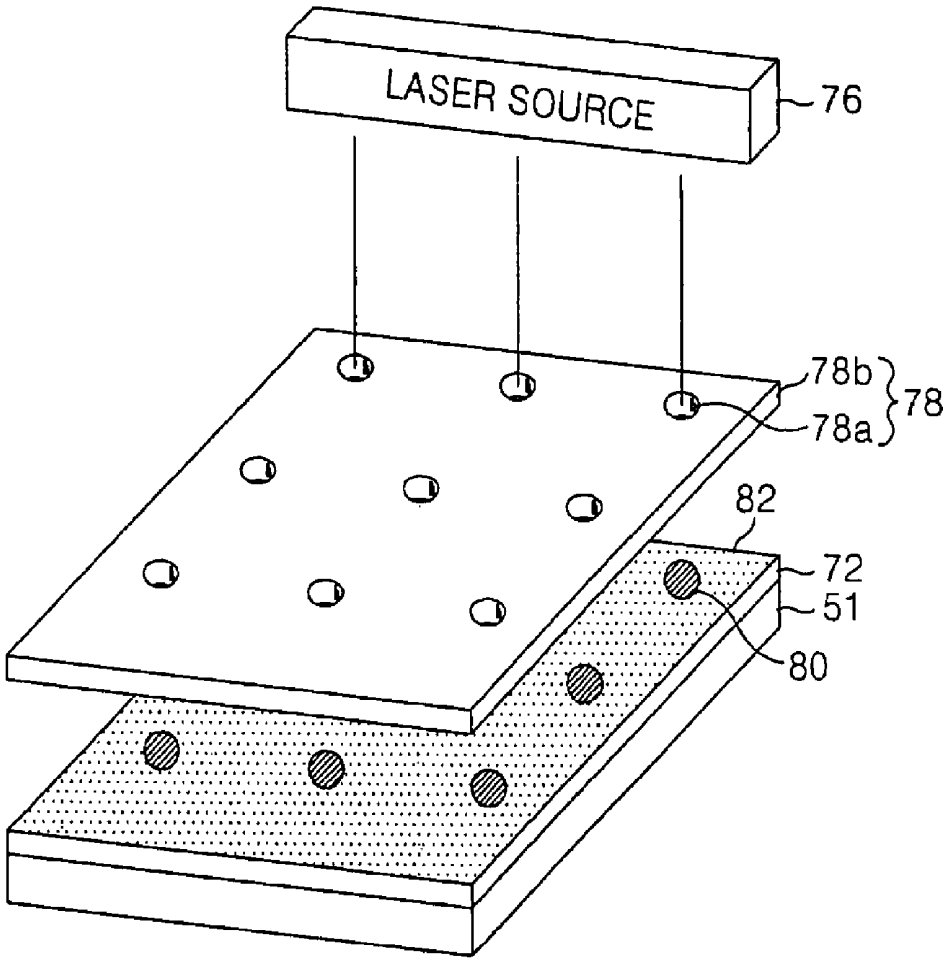


FIG.6C

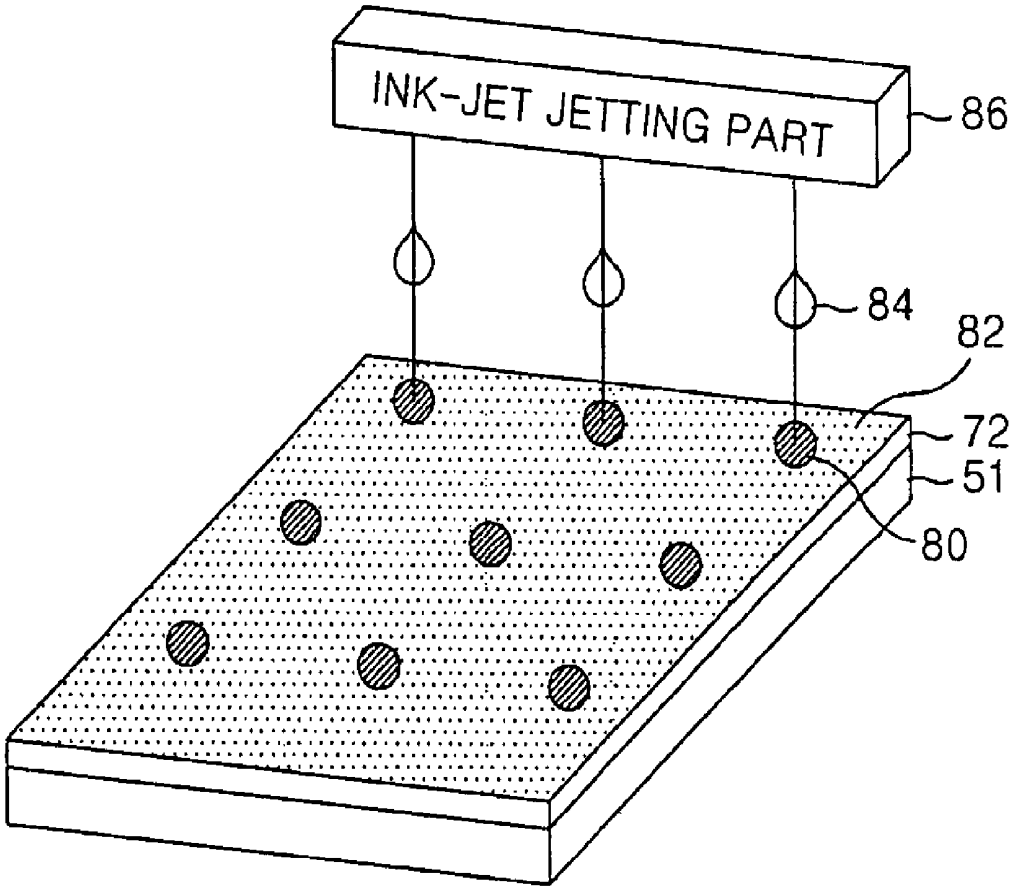


FIG.6D

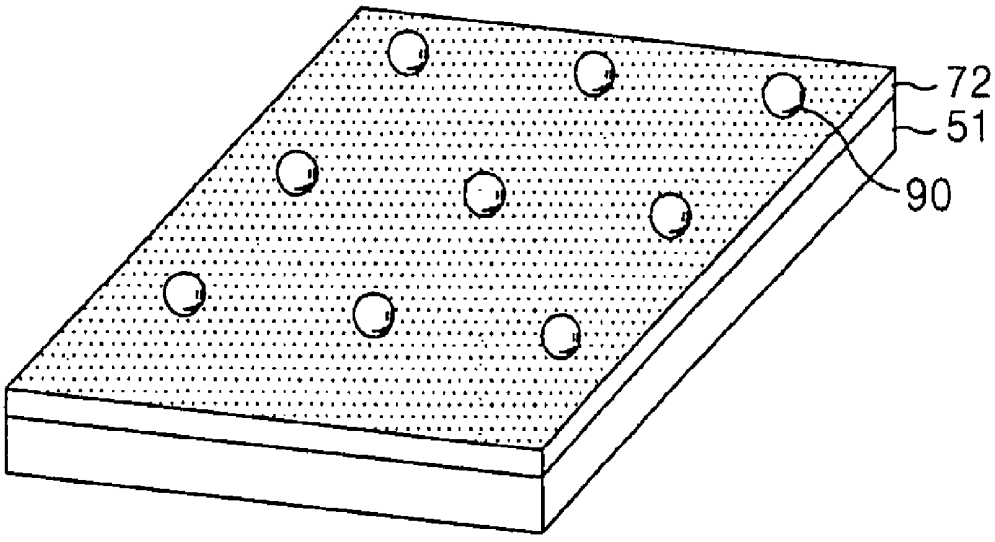
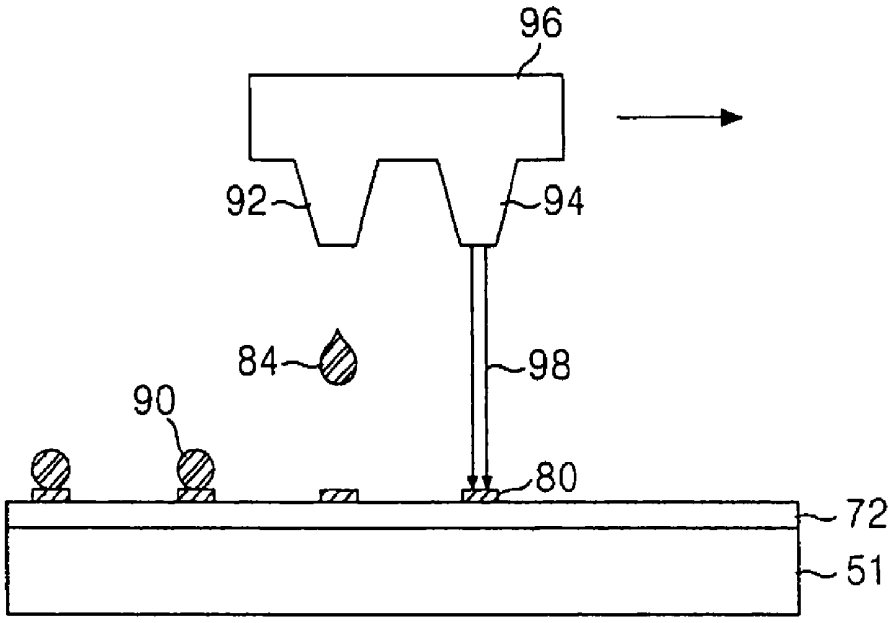


FIG.7



LIQUID CRYSTAL DISPLAY PANEL AND FABRICATING METHOD AND APPARATUS THEREOF

[0001] This application claims the benefit of Korean Patent Application No. P2003-39640 filed in Korea on Jun. 19, 2003, which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a liquid crystal display panel, and more particularly to a liquid crystal display panel that has spacers at desirable locations.

[0004] 2. Description of the Related Art

[0005] Generally, a liquid crystal display (LCD) controls the light transmittance of liquid crystal cells using an electric field to thereby display a picture on a liquid crystal display panel. To this end, the LCD includes a liquid crystal display panel having liquid crystal cells arranged in an active matrix form, and driving circuits for driving the liquid crystal panel. The liquid crystal display panel is provided with pixel electrodes and a reference electrode, i.e. common electrode, to supply the electric field to each one of the liquid crystal cells. Usually, while each one of the liquid crystal cells on a lower substrate have an individual pixel electrode, the common electrode is formed as an integrated electrode for all of the liquid crystal cells across the entire surface of an upper substrate. Each pixel electrode is connected with a thin film transistor (TFT) that is used for a switching element. The pixel electrode together with the common electrode drives the liquid crystal cell in response to data signals supplied via the TFT.

[0006] FIG. **1** illustrates a simplified structure of a related art liquid crystal display panel. As shown in FIG. **1**, a typical liquid crystal display panel includes coupled upper and lower array substrates **10** and **20**, and liquid crystal material **8** between the upper and the lower array substrates **10** and **20**. The liquid crystal material **8** rotates in response to an electric field supplied to thereby regulate the transmittance of incident light coming through the lower array substrate **20**.

[0007] The upper array substrate **10** includes a color filter **4** and a common electrode **6** formed on the rear surface of the upper substrate **1**. The color filter **4**, where red (R), green (G), and blue (B) colored filter layers arranged in the form of stripe make it possible to display colors by selectively passing the light through these colored filters. A black matrix **2** is placed between the adjacent colored filters **4**, and prevents the degradation of the contrast ratio by absorbing the light from the adjacent cells.

[0008] The lower array substrate **20** includes: a data line **18** and gate line **12** that are crossed and are insulated by a gate insulating layer formed on the entire surface of the lower substrate **21**; a TFT **16** placed adjacent the crossing of the data and gate lines **18** and **12**; and a pixel electrode **14** contacting the TFT **16**. In response to gate signals from the gate line **12**, the TFT **16** selectively supplies the pixel electrode **14** with data signals from the data line **18**. The TFT **16** is composed of: a gate electrode connected to the gate line **12**; a source electrode connected to the data line **18**; and a drain electrode connected to the pixel electrode **14**.

[0009] The pixel electrode **14** is made from transparent conductive material having high light transmittance, and is placed within the cell region defined by the data line **18** and gate line **12**. Data signals supplied to the pixel electrode **14** via the drain electrode generate electric potential difference between the pixel and common electrodes **14** and **6**. Under the influence of this electric potential difference, the liquid crystals residing between the upper and lower substrates **1** and **21** rotate due to the dielectric anisotropy thereof. Hence, the light supplied from a light source under the lower substrate **21** passes through the liquid crystals toward the upper substrate **1**.

[0010] The cell gap between these upper and lower array substrates **10** and **20** is maintained by spacers, which are made through a manufacturing process illustrated in FIGS. **2***a* to **2***d*. As shown in FIG. **2***a*, mixed material of solvent, binder, monomer, and photo-initiator is printed onto a substrate **11**. The mixed material is dried so as to evaporate the solvent such that a spacer material **26***a* is formed. The substrate **11** is either a lower substrate having TFTs and pixel electrodes installed thereon or an upper substrate having color filters installed thereon.

[0011] A photoresist **32** is coated on the substrate **11** having the spacer material **26***a* formed thereon. Then, a photomask MS is aligned, as shown in FIG. **2***b*. The photomask MS includes a mask substrate **34**. A shielding layer **36** is formed on the mask substrate **34** so as to overlap with a shielding part S**1**. The transparent mask substrate **34** of the photomask MS is exposed at the exposure part S**2**. By carrying out the exposure process to selectively irradiate ultraviolet rays onto the photoresist **32** using the photomask MS and the development process to develop the exposed photoresist, a photoresist pattern **38** is formed, as shown in FIG. **2***c*. The spacer material **26***a* is patterned through an etching process using the photoresist pattern **38** as a mask, and consequently, a pattern spacer **26** having designated height is formed, as shown in FIG. **2***d*.

[0012] The pattern spacer **26** of the related art LCD occupies only about 2% of the area of the substrate **11**. More than 95% of the spacer material **26***a* that was been printed on the entire surface of the substrate **11** to form the pattern spacer **26** is removed during the subsequent processes of exposure, development, and etching. Thus, a lot of spacer material is wasted, which increases the costs of material and fabrication. Further, the additional mask process for forming the pattern spacer **26** including sub-processes, such as printing, exposure, development, and etching, leads to the problem of making the fabricating process even more complex.

[0013] In order to solve these problems, a fabricating method for the spacer using an ink-jet device has been suggested as shown in FIGS. **3***a* to **3***c*. First, as shown in FIG. **3***a*, an ink-jet device **40** is aligned so as to overlap with the location where the spacer is to be formed on the substrate **11**. Here, the substrate **11** is either a lower substrate **21** having TFTs **16** and pixel electrodes **14** installed thereon or an upper substrate **1** having color filters **4** installed thereon. Then, the spacer material **26***a* is jetted onto the substrate **11** from the ink-jet device **40**. In other words, when an external voltage is supplied to a piezoelectric element of the ink-jet head, physical pressure is generated. This physical pressure causes the conduit **44** connecting the tank **42** containing the spacer material **26***a* with the nozzle **46** to contract and relax repeatedly, and thereby the spacer material **26***a* is jetted to the substrate **11** through the nozzle **46**, as shown in FIG. **3**B.

[0014] The spacer **26** formed by the spacer material jetted through the nozzle **46** of ink-jet device thereafter undergoes

an exposure to the ultraviolet ray radiated from a light source **48** or a firing process as shown in FIG. **3***c*, and then cures to have a width W and height H.

[0015] During the formation of the spacer using the related art ink-jet device, the spacer material **26***a* of low viscosity experiences the gravity while being jetted to the substrate **11**. Due to the effect of gravity, upon arriving at the substrate **11** the spacer material **26***a* spreads out too widely and results in an undesirably small ratio of height H to width W. This leads to the problem of the spacer **26** being formed to overlap with the black matrix **2** so as to encroach into areas that are not overlapped with the black matrix **2**, such as the display area, and appears as a stain on the display area.

SUMMARY OF THE INVENTION

[0016] Accordingly, the present invention is directed to a liquid crystal display panel that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

[0017] An object of the present invention is to provide a liquid crystal display panel and a fabricating method and an apparatus thereof that reduce the amount of material used in forming spacers at desired locations.

[0018] Another object of the present invention is to provide a liquid crystal display panel and a fabricating method and an apparatus thereof that reduce the number of masks used in forming spacers at desired locations.

[0019] Another object of the present invention is to provide a liquid crystal display panel and a fabricating method and an apparatus thereof that consistently forms spacers of an adequate size at desired locations.

[0020] Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0021] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, there is provided a liquid crystal display panel including a substrate having a plurality of layers formed thereon, and having a first surface region and a second surface region on a surface of an uppermost layer of the plurality of layers, wherein the first and second surface regions having different surface characteristics in reaction to a particular liquid, and a spacer formed on the second surface region.

[0022] In another aspect, a method of fabricating a liquid crystal display panel includes: forming a plurality of layers on a substrate; forming a first surface region by applying a first surface process to a surface of an uppermost layer of the plurality of layers formed on the substrate; forming a second surface region having different surface characteristic in reaction to a particular liquid than the first surface region by applying a second surface process to a portion of the surface of the uppermost layer of the plurality of layers formed on the substrate; and forming a spacer using an ink-jet method.

[0023] In yet another aspect, an apparatus for fabricating a liquid crystal display panel includes: a first surface processing part for forming a first surface region by applying a first surface process to an uppermost layer of a plurality of layers formed on a substrate; and a spacer jetting part for forming a second surface region within the first surface region by applying a second surface process to a designated portion of the first surface region and for jetting spacer material onto the second surface region, wherein the second surface process makes the second surface region different from the first surface region in that the second surface region has different surface characteristics in reaction to a particular liquid than the first surface region.

[0024] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] These objects and other advantages of the invention will be apparent from the following detailed description of the embodiments of the present invention with reference to the accompanying drawings.

[0026] FIG. **1** is a perspective view showing the schematic structure of a related art liquid crystal display panel.

[0027] FIGS. **2***a* to **2***d* are sectional views representing a fabricating process for a pattern spacer of FIG. **1**.

[0028] FIGS. **3***a* to **3***c* depict the process for manufacturing the spacer using a related art ink-jet device.

[0029] FIG. **4** is a cross sectional view illustrating the upper substrate of a liquid crystal display panel according to an embodiment of the present invention.

[0030] FIG. **5** is a cross sectional view illustrating the upper substrate of a liquid crystal display panel according to another embodiment of the present invention.

[0031] FIGS. **6***a* to **6***d* are plane views representing steps of a manufacturing process for an upper plate of the liquid crystal display panel of FIGS. **4** and **5**.

[0032] FIG. **7** is a sectional view showing a manufacturing apparatus for the liquid crystal display panel, which is an integration of the ink-jet jetting part and the laser irradiating part.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0033] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings

[0034] FIG. **4** is a cross sectional view illustrating a liquid crystal display of vertical electric field mode panel according to an embodiment of the present invention. As shown in FIG. **4**, the liquid crystal display panel of vertical electric field mode includes a black matrix **52**, a color filter **60**, a planarization layer **54**, a common electrode **58**, and a spacer **56**, which are sequentially formed on an upper substrate **51**.

[0035] The black matrix **52** partitions the upper substrate **51** into a plurality of cell regions in which the color filters **60** are to be formed, and plays a role of preventing the interference of light between adjacent cells. This black matrix **52** is formed so as to overlap areas of a lower array substrate (not shown) that does not include the pixel electrode, such as the areas having TFTs, gate lines, and data lines:

[0036] The color filter **60** is formed in the cell region defined by the black matrix **52**. The color filter **60** is formed using separate red R, green G, and blue B filters to realize red, green, and blue colors. A planarization layer **54** is made of organic insulating material and planarizes the upper substrate **51** having the color filter **60** installed thereon. A flat common electrode **58** is formed on the planarization layer **54**. A refer-

ence voltage for driving the liquid crystal is applied to the common electrode **58**. The common electrode **58** is made from transparent conductive material, such as ITO, In_2O_3 compound, ZnO compound, In_2O_3—ZnO, and PEDOT.

[0037] A uniform electric field is applied to the liquid crystal through the common electrode **58** planarized by the planarization layer **54**. The liquid crystal is driven by the vertical electric field formed between the common electrode **58** and the pixel electrode installed on the lower substrate. The surface **62** of the common electrode **58** is divided into a hydrophilic region **80** and a hydrophobic region **82**. The hydrophilic region **80** is formed so as to overlap with the black matrix **52**, and the hydrophobic region **82** is formed on the rest of the common electrode **58**, such as the region of the common electrode **58** that do not overlap the black matrix **52**. Here, the hydrophilic region **80** can be a polygonal shape or a circular, and the length of diameter or diagonal thereof is in the range of about 10~70 microns (μm).

[0038] The spacer **56** maintains the cell gap between the upper substrate **51** and the lower substrate. The spacer **56** is formed on the upper substrate **51** using an ink-jet method so as to overlap with at least one of a gate line, a data line, and a TFT. This spacer **56** is formed on the hydrophilic region **80** of the common electrode **58** or the planarization layer **54**, and the shape thereof can be either a circle or an oval.

[0039] FIG. **5** is a cross sectional view illustrating the upper array substrate of a liquid crystal display panel of the horizontal electric field mode according to the second embodiment of the present invention. As shown in FIG. **5**, the liquid crystal display panel adopting the horizontal electric field according to the present invention has constituent parts identical to that using the vertical electric field of FIG. **4**, except the common electrode for driving the liquid crystal using the horizontal electric field is installed on the lower substrate. Hence, in the liquid crystal display panel of the horizontal electric field according to embodiments of the present invention, the spacer **56** is formed on the uppermost layer, the planarization layer **54**.

[0040] The surface **62** of the planarization layer **54** is divided into a hydrophilic region **80**, which overlaps the black matrix **52**, and a hydrophobic region **82**, which does not overlap the black matrix **52**. The hydrophilic region **80** can be either a polygonal shape or a circular shape, and the length of diameter or diagonal thereof is in the range of about 10~70 microns (μm). A spacer **56**, made of a hydrophilic material, is formed on the hydrophilic region **80** of the planarization layer **54**, and maintains the cell gap between the upper substrate **51** and the lower substrate.

[0041] FIGS. **6***a* to **6***d* are perspective views representing the manufacturing process for an upper plate of the liquid crystal display panel according to the first and the second embodiments of the present invention. As shown in FIG. **6***a*, a first surface process is applied to the uppermost layer **72** of several layers formed on the upper substrate **51**. The uppermost layer **72** is the common electrode in the case of the liquid crystal display panel of the vertical electric field type, as shown in FIG. **4**. Alternatively, the uppermost layer **72** is the planarization layer in the case of the crystal display panel of the horizontal electric field mode, as shown in FIG. **5**.

[0042] More specifically, after the upper substrate **51** is placed in a vacuum chamber, a hydrophobic mixed gas **74** flows into the vacuum chamber through a gas supplying part **70**. Here, a gas of fluorine compound such as CF_4 or SF_6 is used for the hydrophobic mixed gas. Afterwards, the fluorine compound gas is dissolved into plasma, and then the dissolved fluorine is deposited on the uppermost layer **72**, the common electrode or the planarization layer. Thus, the entire surface of the uppermost layer **72** becomes the hydrophobic region, which completes the first surface process to the uppermost layer **72**. The first surface process may be carried out using a normal atmospheric pressure method rather than in a vacuum chamber.

[0043] As shown in FIG. **6***b*, a second surface process is applied to a designated portion of the uppermost layer **72** which has already been subjected to the first surface process. More specifically, a mask **78** and a laser source **76** are aligned above the first surface processed uppermost layer **72**. Here, the mask **78** has a transmission part **78***a* that overlaps with the black matrix (not shown) formed on the upper substrate **51**, and a shielding part **78***b* that covers the other regions, which are not overlapped by the black matrix.

[0044] A laser beam of relatively short wavelength is generated from the laser source **76** that passes through the transmission part **78***a* of the mask **78**. The wavelength of the laser beam is in the range of about 10~390 nanometers. The exposed portion of the first surface processed uppermost layer **72** becomes a hydrophilic region **80**. In other words, the hydrophobic portion of the surface of the uppermost layer **72** that overlaps with the black matrix is exposed to the laser beam, and becomes the hydrophilic region **80**, which completes the second surface process.

[0045] As shown in FIG. **6***c*, an ink-jet jetting part **86** is aligned above the second surface processed uppermost layer **72**. The ink-jet jetting part **86** jets hydrophilic spacer material **84** onto the uppermost layer **72**. In this case, the hydrophilic spacer material **84** has higher affinity with the hydrophilic region **80** than with the hydrophobic region **82** of the surface of the uppermost layer **72**, which causes the hydrophilic spacer material **84** to stay within the hydrophilic region **80**. Also, the surface tension between the hydrophobic region **82** and hydrophilic spacer material **84** causes some of the hydrophilic spacer material **84** that may have jetted onto the hydrophobic region **82** to move toward the hydrophilic region **80**. Afterwards, the spacer material within the hydrophilic region **80** is hardened by an ultraviolet ray or a heater, then the spacer **90** with designated height is formed as shown in FIG. **6***d*.

[0046] On the other hand, the ink-jet jetting part **86** and the laser source **76** respectively shown in FIGS. **6***b* and **6***c* may be incorporated in a single unit, such as the spacer maker **96** shown in FIG. **7**. Namely, the spacer maker **96** includes an ink-jet jetting nozzle **92** and a laser irradiation nozzle **94**. The laser irradiation nozzle **94** irradiates a laser beam **98** of short wavelength onto the hydrophobic region of the uppermost layer **72** so as to change the irradiated region into a hydrophilic region **80**. Meanwhile, the ink-jet jetting nozzle **92** jets the spacer material **84** onto the hydrophilic region so as to form a spacer. The spacer maker **96** aligned above the substrate **51** is then moved to form the next spacer **90** on the hydrophobic region **80**.

[0047] The laser source **76** in FIG. **6***b*, the ink-jet jetting part **86** in FIG. **6***c* can be combined like the ink-jet jetting nozzle **92** in FIG. **7** and laser irradiation nozzle **94** in FIG. **7** to have corresponding nozzles in a single unit, to thereby further shorten the process time. On the other hand, the liquid crystal display panel, the fabricating method thereof, and the fabricating apparatus thereof according to the present invention can be used to make the region that overlaps with the black matrix be hydrophobic and other region be hydrophilic, and

form a spacer at the hydrophobic region by jetting hydrophobic spacer material to the hydrophobic region.

[0048] As mentioned above in detail, the liquid crystal display panel, the fabricating method thereof, and the fabricating apparatus thereof according to the present invention forms spacers using an ink-jet device. This reduces the number of mask processes and simplify the manufacturing process. Also, a liquid crystal display panel and a fabricating method thereof according to the present invention jet spacer material onto the substrate that is divided into hydrophilic and a hydrophobic regions. This leads to forming spacers of designated height on the hydrophilic regions, which overlap the black matrix. Thus, the spacers of a desired height can be formed at desired regions. Additionally, the integration of a ink-jet jetting part and a laser source can further shorten the manufacturing time.

[0049] Although the present invention has been explained by the embodiments shown in the drawings described above, it should be understood to the ordinary skilled person in the art that the invention is not limited to the embodiments, but rather that various changes or modifications thereof are possible without departing from the spirit of the invention. Accordingly, the scope of the invention shall be determined only by the appended claims and their equivalents.

1. A liquid crystal display panel, comprising:

a substrate having a plurality of layers formed thereon, and having a first surface region and a second surface region on a surface of an uppermost layer of the plurality of layers, wherein the first and second surface regions having different surface characteristics in reaction to a particular liquid; and

a spacer formed on the second surface region.

2. The liquid crystal display panel according to claim **1**, wherein the plurality of layers comprise:

a black matrix formed on the substrate;

a color filter formed on the region divided by the black matrix; and

a planarization layer formed on the color filter, wherein the second surface region overlaps the black matrix.

3. The liquid crystal display panel according to claim **1**, wherein the plurality of layers comprise:

a black matrix on the substrate underneath the second surface region;

a color filter formed on the region divided by the black matrix;

a planarization layer formed on the color filter; and

a common electrode formed on the planarization layer.

4. The liquid crystal display panel according to claim **3**, wherein the common electrode comprises one of ITO, In_2O_3 compound, ZnO compound, In_2O_3—ZnO, and PEDOT.

5. The liquid crystal display panel according to claim **1**, wherein the first surface region has a hydrophobic property and the second surface region has a hydrophilic property.

6. The liquid crystal display panel according to claim **1**, wherein the spacer is made from hydrophilic material and is formed on the second surface region.

7. The liquid crystal display panel according to claim **1**, wherein the second surface region has a width in a range of about 10~70 microns (μm).

8. The liquid crystal display panel according to claim **1**, wherein the spacer is formed using an ink-jet method.

9-21. (canceled)

22. An apparatus for fabricating a liquid crystal display panel, comprising:

a first surface processing part for forming a first surface region by applying a first surface process to an uppermost layer of a plurality of layers formed on a substrate; and

a spacer jetting part for forming a second surface region within the first surface region by applying a second surface process to a designated portion of the first surface region and for jetting spacer material onto the second surface region,

wherein the second surface process makes the second surface region different from the first surface region in that the second surface region has different surface characteristics in reaction to a particular liquid than the first surface region.

23. The apparatus for fabricating a liquid crystal display panel according to claim **22**, wherein the first surface processing part makes the surface of the uppermost layer to be hydrophobic by using a fluorine compound gas.

24. The apparatus for fabricating a liquid crystal display panel according to claim **22**, wherein the spacer jetting part comprises:

a second surface process part for causing a portion of the uppermost layer of the plurality of layers to become the second surface region; and

a jetting part for jetting spacer material onto the second surface region.

25. The apparatus for fabricating a liquid crystal display panel according to claim **22**, wherein the second surface process part changes a portion of the surface that is part of the first surface region into the second surface region by irradiating rays with a predetermined range of wavelengths onto the portion of the surface.

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专利名称(译)	液晶显示面板及其制造方法和设备		
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摘要(译)

所公开的发明涉及一种液晶显示面板，该液晶显示面板包括其上形成有多个层的基板，并且在所述多个层的最上层的表面上具有第一表面区域和第二表面区域，其中第一层第二表面区域具有与特定液体反应的不同表面特征，以及形成在第二表面区域上的间隔物。