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(54) CURVED LIQUID CRYSTAL DISPLAY
DEVICE AND COLOR FILTER SUBSTRATE
FOR THE SAME

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

G02F 1/1333 (2006.01)
G02B 5/20 (2006.01)
G02F 1/1362 (2006.01)
G02F 1/1335 (2006.01)

(52) U.S. Cl.

CPC **G02B 5/201** (2013.01); **G02F 1/133512**
(2013.01); **G02F 1/136286** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(57) **ABSTRACT**

A curved liquid crystal display device includes first and second substrates facing each other and including a central region and a peripheral region; a plurality of data lines disposed on the first substrate and being spaced apart from each other by the same distance; a plurality of gate lines disposed on the first substrate and crossing the plurality of data lines; a pixel electrode disposed on the first substrate; a common electrode on the first substrate or the second substrate; a plurality of black matrixes disposed on the second substrate, a distance between adjacent black matrixes in the central region being smaller than a distance between adjacent black matrixes in the peripheral region; and a liquid crystal layer disposed between the first and second substrates.

8 Claims, 10 Drawing Sheets

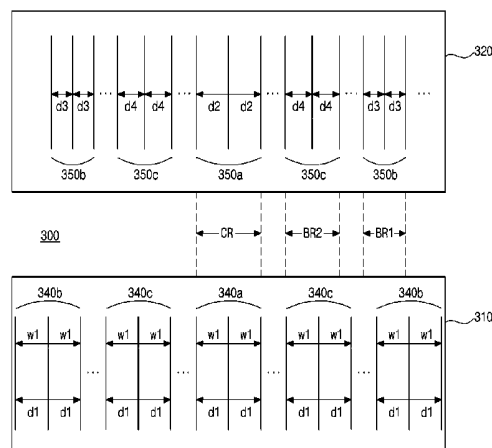
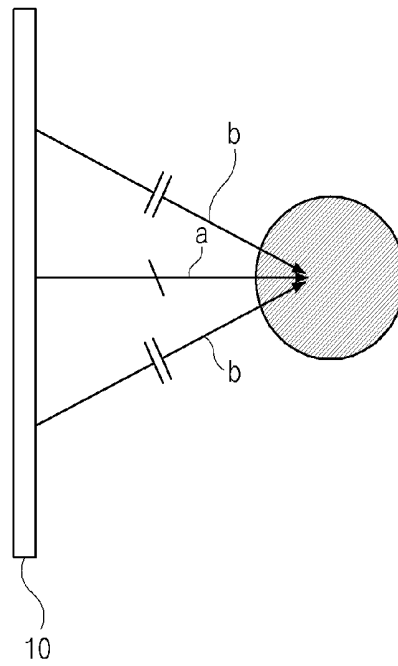


FIG. 1
RELATED ART



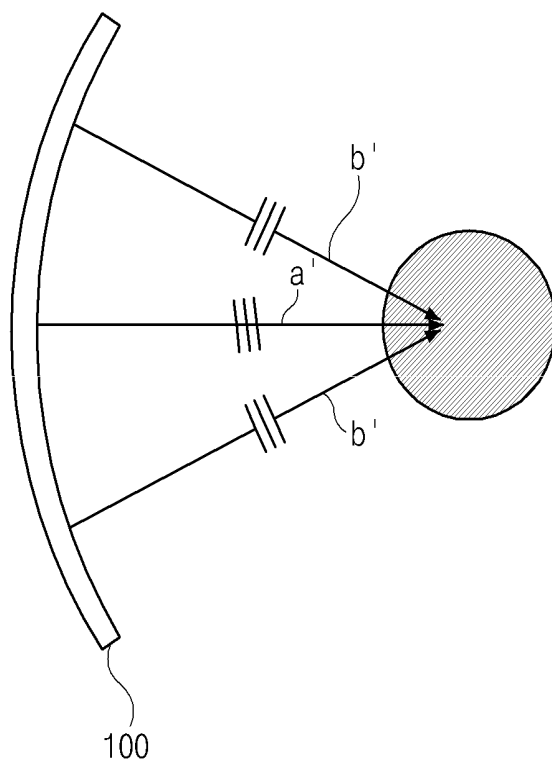
**FIG. 2**

FIG. 3

100

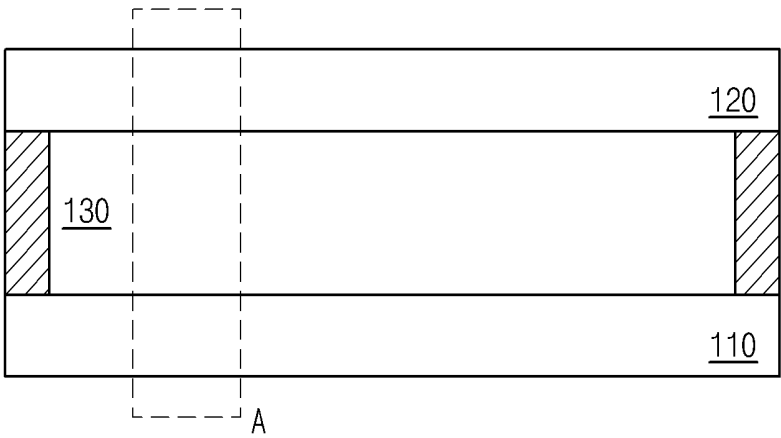


FIG. 4

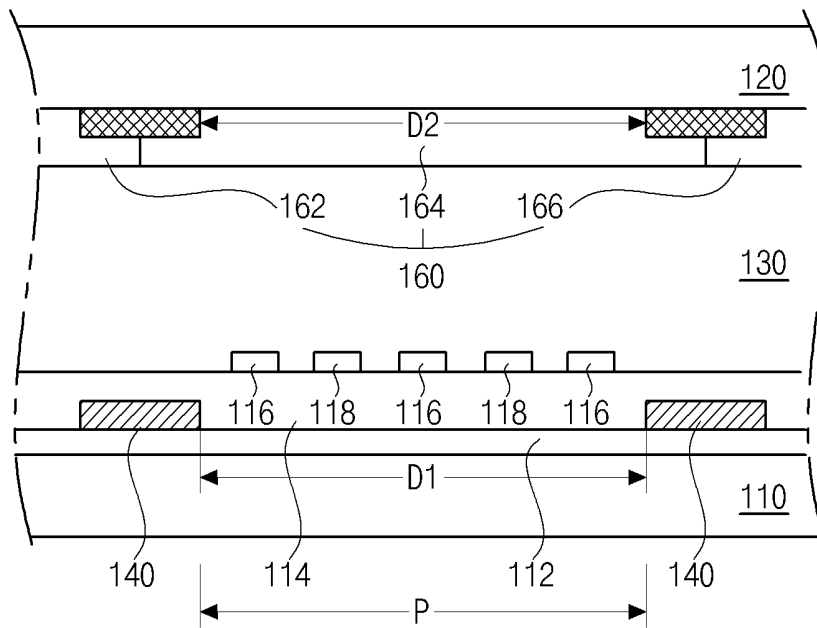


FIG. 5

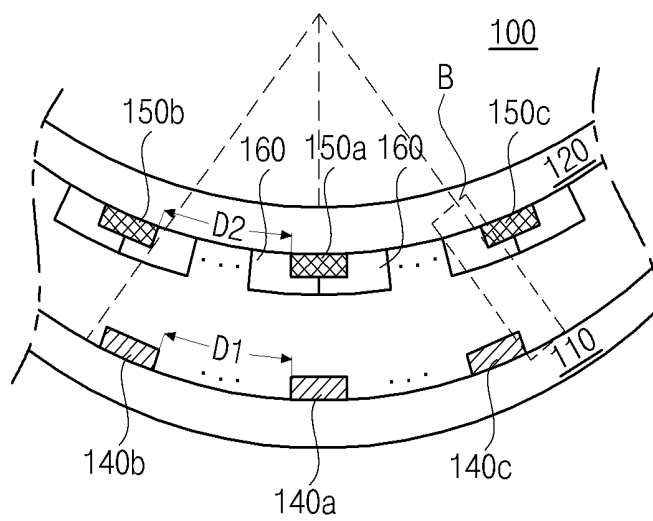


FIG. 6

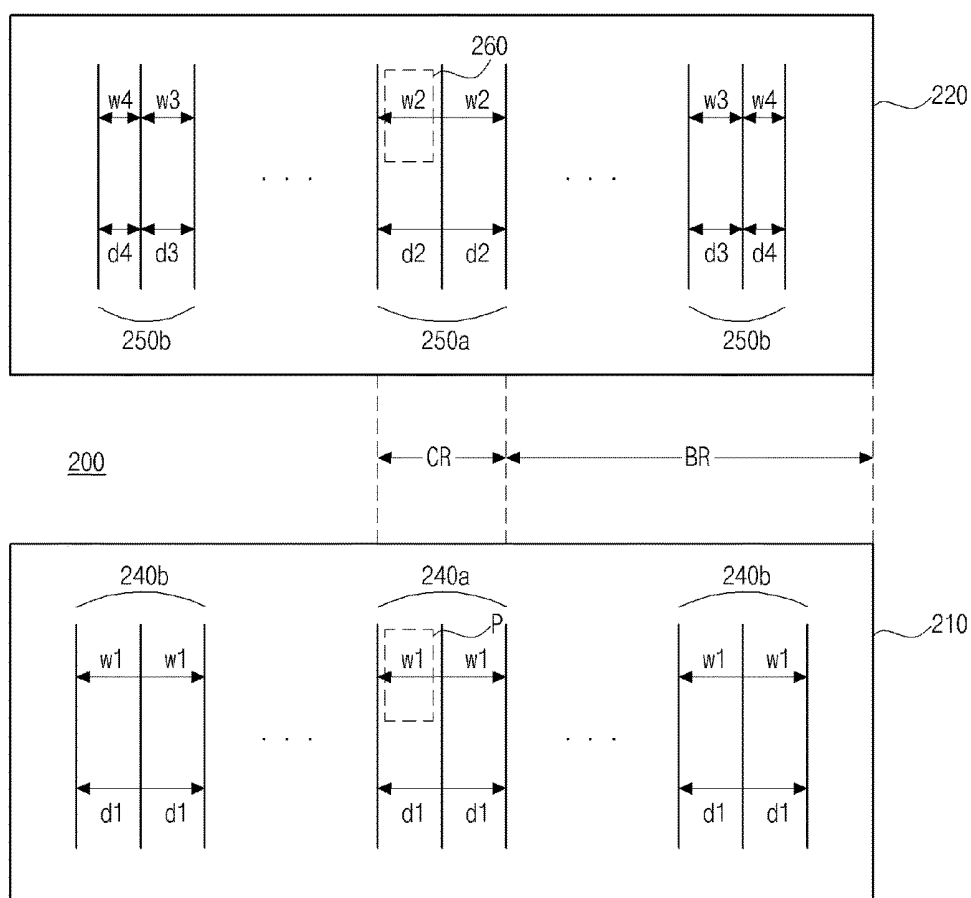


FIG. 7

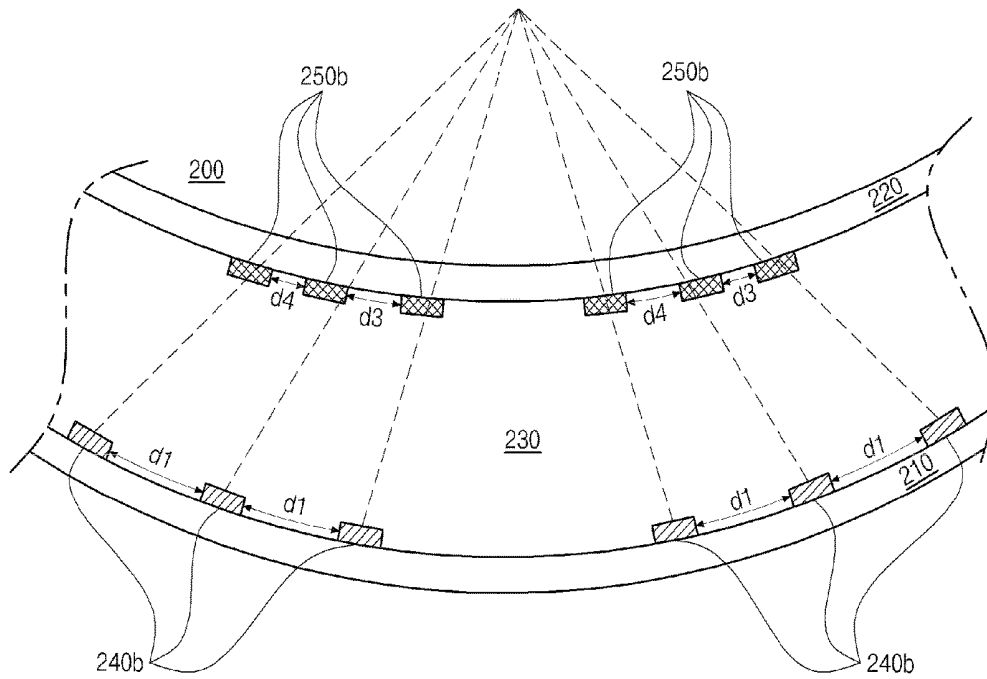


FIG. 8

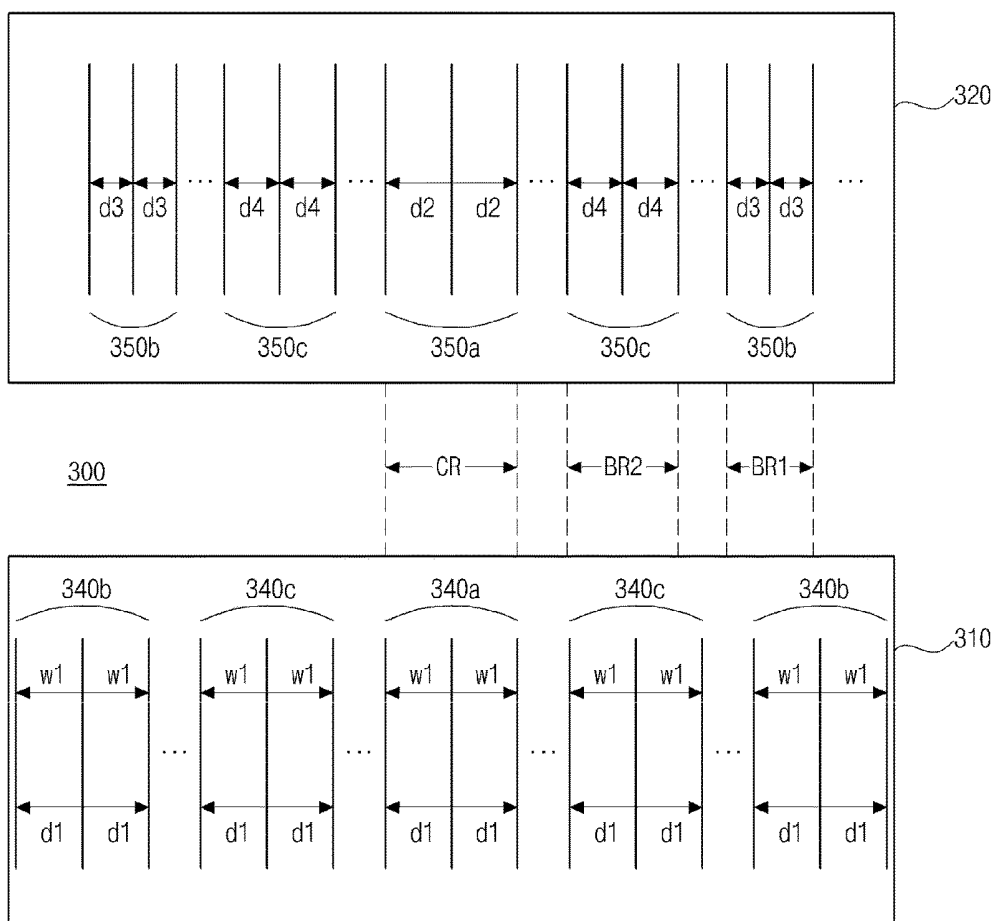


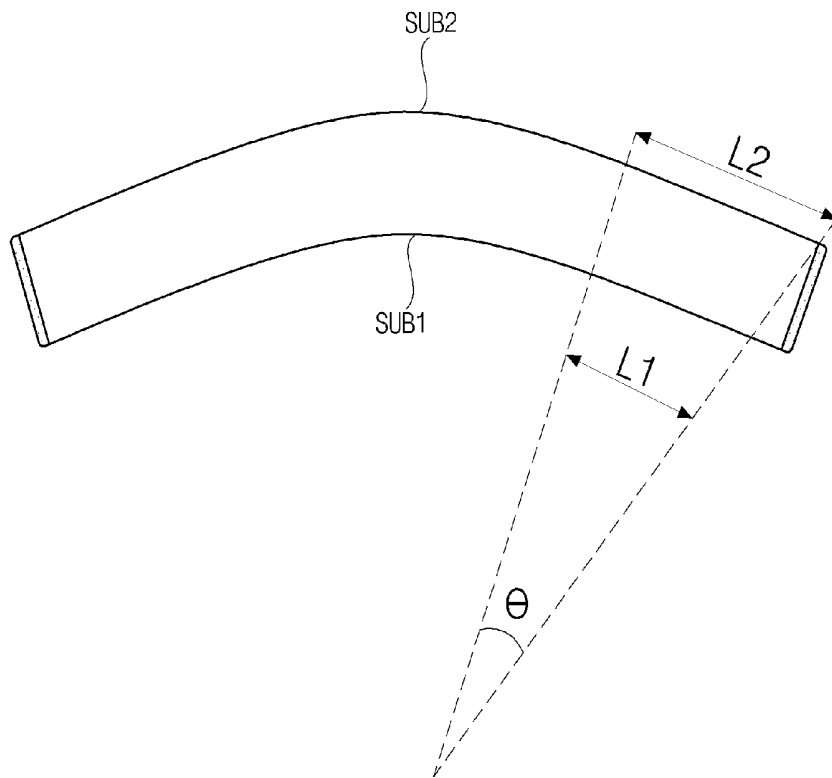
FIG. 9

FIG. 10

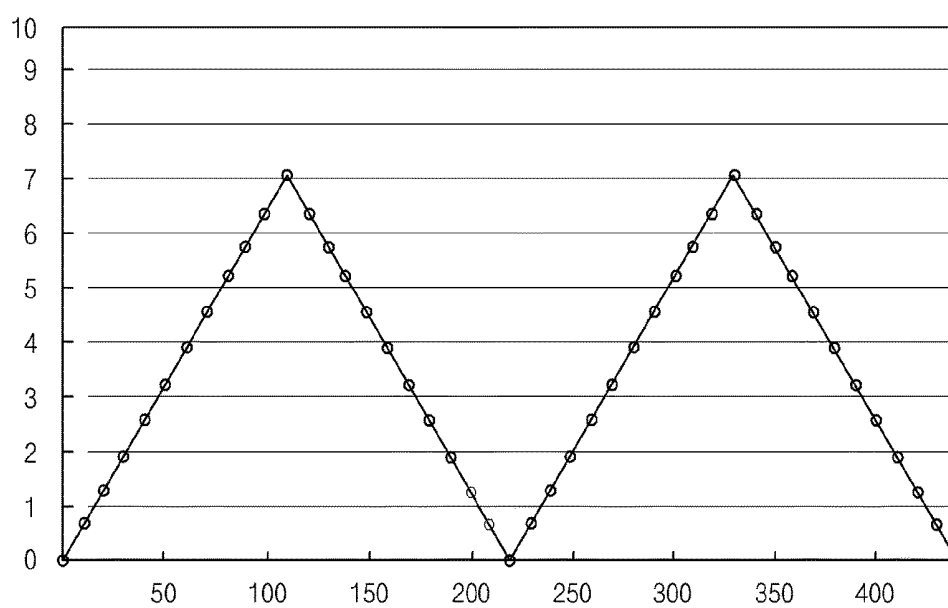
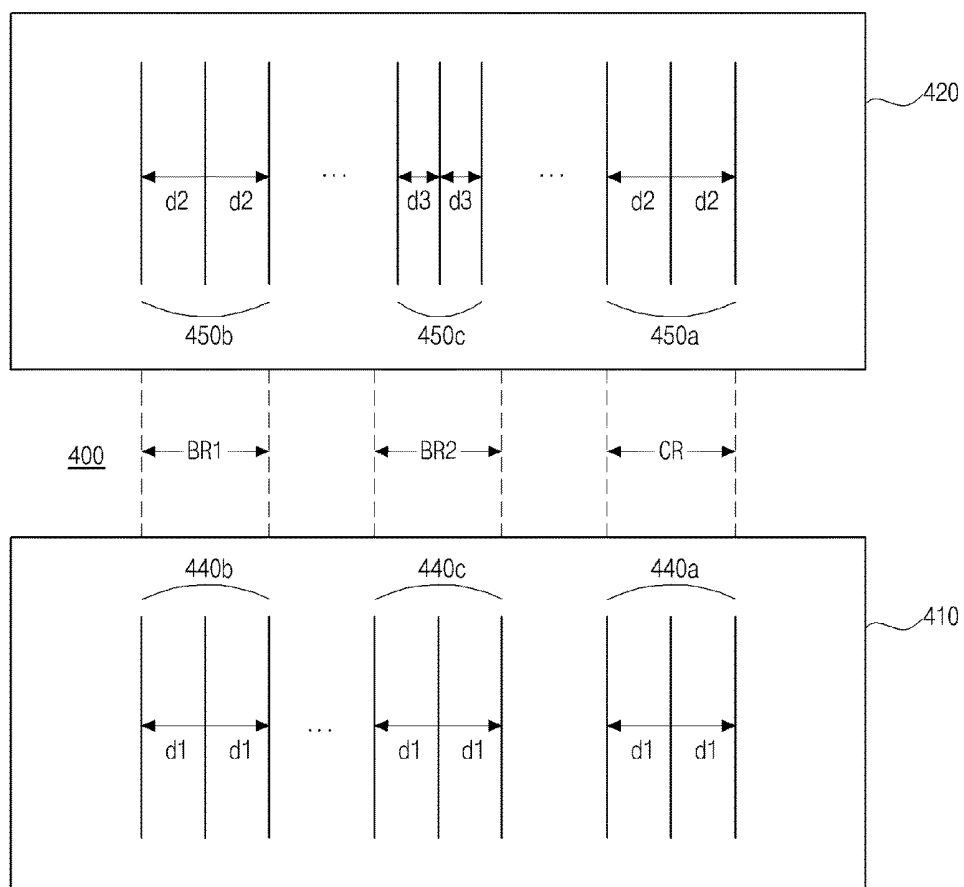


FIG. 11



CURVED LIQUID CRYSTAL DISPLAY DEVICE AND COLOR FILTER SUBSTRATE FOR THE SAME

The present application claims the benefit of Korean Patent Application No. 10-2014-0072282 filed in Korea on Jun. 13, 2014, which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a liquid crystal display (LCD) device and more particularly to a curved LCD device and a color filter substrate for the curved LCD device.

Discussion of the Related Art

As society has entered in earnest upon an information age, various display devices for displaying images are required.

Flat panel display devices, such as an LCD device, a plasma display panel (PDP) and an organic light emitting diode (OLED) display device, have excellent capabilities of a thin profile, light weight and low power consumption, and so on, relative to a cathode ray tube (CRT) device and are widely researched instead of the CRT display.

Among these devices, since the LCD device has advantages in the weight, the size and the power consumption, the LCD device is widely used.

The LCD device includes a liquid crystal panel and a backlight unit. The backlight unit is disposed under the liquid crystal panel and provides the light to the liquid crystal panel. The LCD device uses optical anisotropy and polarization properties of liquid crystal molecules in the liquid crystal panel. The liquid crystal molecules have a definite alignment direction as a result of their thin and long shapes. The alignment direction of the liquid crystal molecules can be controlled by application of an electric field across the liquid crystal molecules.

As the intensity or direction of the electric field is changed, the alignment of the liquid crystal molecules also changes. Since incident light is refracted based on the orientation of the liquid crystal molecules due to the optical anisotropy of the liquid crystal molecules, images can be displayed by controlling light transmissivity.

Since the LCD device including a thin film transistor (TFT) as a switching element, referred to as an active matrix LCD (AM-LCD) device, has excellent characteristics of high resolution and displaying moving images, the AM-LCD device has been widely used.

On the other hand, there is a distance deviation in the related art LCD device.

Namely, with reference to FIG. 1, which shows the related art LCD device, there is a difference between a first distance "a" from a main viewing point to a center of the LCD device 10 and a second distance "b" from the main viewing point to a side of the LCD device 10. Namely, there is the distance deviation in the flat type display device.

SUMMARY

Accordingly, the present invention is directed to a curved LCD device and a color filter substrate for the same that substantially obviate one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a curved LCD device and a color filter substrate for the same that is capable of preventing a distance deviation.

An object of the present invention is to provide a curved LCD device and a color filter substrate for the same that is capable of preventing a light leakage problem without aperture ratio decrease.

An object of the present invention is to provide a curved LCD device and a color filter substrate for the same that is capable of preventing a color mixture problem without transmittance decrease.

An object of the present invention is to provide a curved LCD device and a color filter substrate for the same that is capable of preventing a color mixture problem, a light leakage problem and a transmittance decrease problem without aperture ratio decrease.

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.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, a curved liquid crystal display device comprises first and second substrates facing each other and including a central region and a peripheral region; a plurality of data lines disposed on the first substrate and being spaced apart from each other by the same distance; a plurality of gate lines disposed on the first substrate and crossing the plurality of data lines; a pixel electrode disposed on the first substrate; a common electrode on the first substrate or the second substrate; a plurality of black matrixes disposed on the second substrate, a distance between adjacent black matrixes in the central region being smaller than a distance between adjacent black matrixes in the peripheral region; and a liquid crystal layer disposed between the first and second substrates.

In another aspect, a curved liquid crystal display device comprises first and second substrates facing each other and including a central region and a first peripheral region; a plurality of data lines disposed on the first substrate and being spaced apart from each other by a first distance; a plurality of gate lines disposed on the first substrate and crossing the plurality of data lines; a pixel electrode disposed on the first substrate; a common electrode on the first substrate or the second substrate; a black matrix disposed on the second substrate and including first black matrixes in the central region and second black matrixes in the first peripheral region; and a liquid crystal layer disposed between the first and second substrates, wherein the first black matrixes are spaced apart from each other by a second distance, and the second black matrixes are spaced apart from each other by a third distance being smaller than the second distance.

In another aspect, the present invention provides a curved liquid crystal display device including first and second substrates facing each other and including a central region and a peripheral region; a plurality of gate lines disposed on the first substrate; a plurality of data lines disposed on the first substrate and crossing the plurality of data lines; a pixel electrode disposed on the first substrate or the second substrate; a common electrode on the first substrate or the second substrate; a black matrix disposed on the second substrate and corresponding to the plurality of data lines; a color filter layer disposed on the second substrate, a width of the color filter being decreased from the central region to the peripheral region; and a liquid crystal layer disposed between the first and second substrates.

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In another aspect, a curved liquid crystal display device comprises first and second substrates facing each other and including a central region and a first peripheral region; a plurality of gate lines disposed on the first substrate; a plurality of data lines disposed on the first substrate and crossing the plurality of data lines; a pixel electrode disposed on the first substrate; a common electrode on the first substrate or the second substrate; a black matrix disposed on the second substrate and corresponding to the plurality of data lines; a color filter layer disposed on the second substrate and including a first color filter in the central region and a second color filter in the first peripheral region; and a liquid crystal layer disposed between the first and second substrates, wherein a first width of the first color filter is larger than a second width of the second color filter.

In another aspect, a color filter substrate for a curved liquid crystal display device comprises a substrate including a central region and a first peripheral region; first black matrixes in the central region and spaced apart from each other by a first distance along a major axis of the substrate; second black matrixes in the first peripheral region and spaced apart from each other by a second distance, which is smaller than the first distance, along the major axis of the substrate; and a color filter layer between the first and second black matrixes.

In another aspect, a color filter substrate for a curved liquid crystal display device comprises a substrate including a central region and a first peripheral region; a black matrix on the substrate and including an opening; and a color filter layer in the opening and including a first color filter in the central region and a second color filter in the first peripheral region, wherein the first color filter has a first width being larger than a second width of the second color filter.

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

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

FIG. 1 shows the related art LCD device.

FIG. 2 is a schematic perspective view of a curved LCD device according to a first embodiment of the present invention.

FIG. 3 is a schematic cross-sectional view showing a flat state of a curved LCD device according to the first embodiment of the present invention.

FIG. 4 is an enlarged view of "A" part in FIG. 3.

FIG. 5 is a schematic cross-sectional view showing a curved state of a curved LCD device according to the first embodiment of the present invention.

FIG. 6 is a schematic plane view showing a flat state of a curved LCD device according to a second embodiment of the present invention.

FIG. 7 is a schematic plane view showing a curved state of a curved LCD device according to the second embodiment of the present invention.

FIG. 8 is a schematic plane view showing a flat state of a curved LCD device according to a third embodiment of the present invention.

FIG. 9 is a schematic view explaining a shift arrangement of a black matrix in a curved LCD device.

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FIG. 10 is a schematic view explaining a shift principle of an upper substrate in a curved LCD device.

FIG. 11 is a schematic plane view showing a flat state of a curved LCD device according to a fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Reference will now be made in detail to the preferred embodiments, examples of which are illustrated in the accompanying drawings.

FIG. 2 is a schematic perspective view of a curved LCD device according to a first embodiment of the present invention.

As shown in FIG. 2, a curved LCD device **100** has a curved shape. Namely, a flat display device is curved by a pre-determined curvature with respect to a center of the display device to be curved shape.

Accordingly, a first distance "a" from a main viewing point to a center of the LCD device **100** is substantially equal to a second distance "b" from the main viewing point to a side of the LCD device **100** such that there is no distance deviation. As a result, a sense of immersion is improved.

FIG. 3 is a schematic cross-sectional view showing a flat state of a curved LCD device according to the first embodiment of the present invention, and FIG. 4 is an enlarged view of "A" part in FIG. 3. FIG. 5 is a schematic cross-sectional view showing a curved state of a curved LCD device according to the first embodiment of the present invention.

A curved LCD device **100** according to the first embodiment of the present invention includes first and second substrates **110** and **120**, which face each other, and a liquid crystal layer **130** therebetween.

A flat state of the LCD device in FIG. 3 is transformed into a curved state of the LCD device in FIG. 5 such that the curved LCD device **100** is provided.

With reference to FIG. 4, a data line **140**, a common electrode **116**, a pixel electrode **118** are formed on the first substrate **110** as a lower substrate, and a black matrix **150** and a color filter layer **160** are formed on the second substrate **120** as an upper substrate.

In more detail, a gate line (not shown), which extends along a direction, and a gate electrode (not shown), which is connected to the gate line, are formed on the first substrate **110**, and a gate insulating layer **112** is formed to cover the gate line and the gate electrode. A common line (not shown) may be further formed to be parallel to the gate line.

In addition, a semiconductor layer (not shown) corresponding to the gate electrode is formed on the gate insulating layer **112**, and a source electrode (not shown) and a drain electrode (not shown), which are spaced apart from each other, are formed on the semiconductor layer. For example, the semiconductor layer may include an active layer of intrinsic amorphous silicon and an ohmic contact layer of impurity-doped amorphous silicon. Alternatively, the semiconductor layer may be formed of an oxide semiconductor material.

The gate electrode, the gate insulating layer, the semiconductor layer, the source electrode and the drain electrode constitute a thin film transistor (TFT).

Moreover, the data line **140** is formed on the gate insulating layer **112**. The data line **140** crosses the gate line to define a pixel region P. In other words, the gate line and the data line **140** extend along boundaries of the pixel region P.

The data line **140** is connected to the source electrode. Namely, the TFT is connected to the gate line and the data line **140**.

A passivation layer **114** is formed to cover the TFT and the data line **140** and includes a drain contact hole (not shown) exposing the drain electrode of the TFT.

The common electrode **116** and the pixel electrode **118** are formed on the passivation layer **114**. The common electrode **116** and the pixel electrode **118** have a bar shape and alternately arranged.

A common contact hole (not shown), which exposes the common line, may be formed through the gate insulating layer **112** and the passivation layer **114**, and the common electrode **116** may be connected to the common line through the common contact hole. The pixel electrode **118** is connected to the drain electrode through the drain contact hole.

In FIG. 4, the common electrode **116** and the pixel electrode **118** are alternately arranged and disposed on the passivation layer **118**. However, a position and a shape of the common electrode **116** and the pixel electrode **118** are not limited thereto.

For example, the common electrode and the pixel electrode may be disposed in a different layer. In this instance, lower one of the common electrode and the pixel electrode may have a plate shape, and upper one of the common electrode and the pixel electrode may include at least one opening. Alternatively, the pixel electrode may be formed on the first substrate, and the common electrode may be formed on the second substrate.

The black matrix **150** and the color filter layer **160** are formed on the second substrate **120**. The black matrix **150** has a lattice shape and includes an opening in correspondence to the pixel region P. Namely, the black matrix **150** is positioned to overlap the data line **140**.

The color filter layer **160** is disposed in the opening of the black matrix **150**. Namely, the color filter layer **160** corresponds to the pixel region P. For example, the color filter layer **160** may include a red color filter pattern **162**, a green color filter pattern **164** and a blue color filter pattern **166**.

In this instance, the data line **140** includes a plurality of lines along boundaries of each pixel region P, and the black matrix **150** also includes a plurality of lines corresponding to the plurality of lines of the data line **140**.

Namely, a first distance "D1" between adjacent lines of the data line **140** is substantially equal to a second distance "D2" between adjacent lines of the black matrix **150**, and a light leakage problem at a periphery of the data line **140** is prevented by the black matrix **150**.

However, when the LCD device is curved, the data line **140** and the black matrix **150** are dislocated and do not overlap such that the light leakage problem is generated at the periphery of the data line **140**.

As shown in FIG. 5, in the curved LCD device **100**, the data line **140a** and the black matrix **150a** in a central region overlap, while the data lines **140b** and **140c** and the black matrixes **150b** and **150c** in the peripheral region are dislocated such that the data lines **140b** and **140c** are not covered by the black matrixes **150b** and **150c**, respectively.

Namely, there is no light leakage problem at peripherals of the data line **140a** in the central region, while there is the light leakage problem at the peripherals of the data lines **140b** and **140c** in the peripheral region.

In the curved LCD device **100**, since the length of the arc corresponding to the length of a surface of the second substrate **120** is smaller than the length of the arc corresponding to the length of a surface of the first substrate **110**, the data lines **140**, which are spaced apart from each other

by the first distance D1, and the black matrixes **150**, which are spaced apart from each other by the second distance being equal to the first distance D1, in a flat state are dislocated in the peripheral region.

In addition, since the data lines **140** and the black matrixes **150** are dislocated in the peripheral region, the light in one pixel region P passes through the color filter layer **160** in adjacent pixel region P. In other words, the color mixture problem is generated. ("B" part)

Moreover, the black matrix **150** is positioned in the pixel region P in the curved state, the transmittance of the curved LCD device is decreased.

On the other hand, the above problems can be overcome by increasing a width of the black matrix **150**. However, the aperture ratio is decreased with increasing the width of the black matrix **150**.

A curved LCD device being capable of preventing a color mixture problem, a light leakage problem and a transmittance decrease problem without aperture ratio decrease and a color filter substrate for the curved LCD device are explained.

FIG. 6 is a schematic plane view showing a flat state of a curved LCD device according to a second embodiment of the present invention.

As shown in FIG. 6, a curved LCD device **200** according to the second embodiment of the present invention includes first and second substrates **210** and **220**, which face each other, and a liquid crystal layer (not shown) therebetween. In the first and second substrates **210** and **220**, a central region CR and a peripheral region BR are defined.

A plurality of data lines **240a** and **240b** are disposed along a vertical direction on the first substrate **210**.

Although not shown, a plurality of gate lines, which cross the data lines **240a** and **240b** to define a plurality of pixel regions P, are disposed on the first substrate **210**, and a TFT, which is connected to corresponding one of the data lines **240a** and **240b** and corresponding one of the gate lines, is disposed in each pixel region P. In addition, a plurality of pixel electrodes, which are connected to the TFT, are formed to be spaced apart from each other on the first substrate **210**, and a plurality of common electrodes, which are alternately arranged with the pixel electrodes, are disposed on the first substrate **210**. The first substrate **210** may be referred to as an array substrate.

The data line includes first data lines **240a** in the central region CR and second data lines **240b** in the peripheral region BR. The first and second data lines **240a** and **240b** are spaced apart from each other by the same distance.

Namely, all of the first and second data lines **240a** and **240b** have a first distance "d1", and each pixel region P, which is defined by the data lines **240a** and **240b** and the gate lines, has a first width "w1".

On the second substrate **220**, a black matrix **250a** and **250b**, which extends to be parallel to the first and second data lines **240a** and **240b** and has an opening in correspondence to the pixel region P, and a color filter layer **160** (of FIG. 4) in the opening of the black matrix **250a** and **250b** are disposed. Although not shown, the black matrix **250a** and **250b** may include horizontal portions corresponding to the gate lines. The second substrate **220** including the black matrix **250a** and **250b** and the color filter layer **160** may be referred to as a color filter substrate. Alternatively, the color filter layer may be formed on the first substrate or omitted.

In this instance, the black matrix includes first black matrixes **250a** in the central region CR and second black matrixes **250b** in the peripheral region BR. The first black

matrixes **250a** have the same distance from each other, while the second black matrixes **250b** have difference distances from each other.

Namely, the first black matrixes **250a** in the central region CR are spaced apart from each other by a second distance "d2", which is substantially equal to the first distance "d1" between the data lines **240a** and **240b**, while the second black matrixes **250b** in the peripheral region BR are spaced apart from each other by a third distance "d3" or a fourth distance "d4", each of which is smaller than the first distance "d1" between the data lines **240a** and **240b**.

In addition, a distance between the second black matrixes **250b** in the peripheral region BR is proportionally decreased to a distance from the first black matrix **250a** in the central region CR. ($d3 > d4$) In other words, the second black matrixes **250b** in the peripheral region BR are shifted toward the central region CR such that the distance between adjacent second black matrixes **250b** is decreased from the central region CR to the peripheral region BR with respect to a curvature direction of the second substrate **220**.

When the color filter layer **160** (of FIG. 4) including the red, green and blue color filter patterns **162**, **164** and **166** (of FIG. 4) is formed in the opening of the black matrixes **250a** and **250b**, a width of the color filter layer **160** between the black matrixes **250a** and **250b** is decreased from the central region CR to the peripheral region BR.

Namely, due to the different distance between the black matrixes **250a** and **250b** have a different distance, the color filter pattern in the central region CR has a second width "w2", which is substantially equal to the first width "w1" of the pixel region "P", while the color filter patterns in the peripheral region "BR" have a third width "w3" or a fourth width "w4", each of which is smaller than the first width "w1" of the pixel region P. ($w3 > w4$)

FIG. 7 is a schematic plane view showing a curved state of a curved LCD device according to the second embodiment of the present invention. The curved LCD device is provided by bending the flat LCD device in FIG. 6.

As shown in FIG. 7, in the curved LCD device **200**, which is bent or curved by a pre-determined curvature, the arc length of the second substrate **220** with respect to an angle is smaller than the arc length of the first substrate **210** with respect to the angle.

Since the first distance "d1" between the second data lines **240b** on the first substrate **210** in the peripheral region BR is larger than each of the third and fourth distances "d3" and "d4" between the second black matrixes **250b** on the second substrate **220** in the peripheral region "BR", a difference between the arc lengths of the first and second substrates **210** and **220** is compensated such that the second black matrix **250b** overlaps the second data line **240b**.

Namely, the difference in the arc length, which is generated by the curvature of the curved LCD device, is compensated by the shift arrangement of the second black matrixes **250b** such that the mis-alignment between the second black matrix **250b** and the second data line **240b** in the peripheral region BR is prevented. Accordingly, the light leakage at the periphery of the second data line **250b** is not generated.

In addition, since the pixel region P and the color filter layer are accurately matched without the mis-alignment between the second black matrix **250b** and the second data line **240b**, the color mixture problem by the light in adjacent pixel region P is prevented.

Namely, by shifting the second black matrixes **250b** in the peripheral region BR into the central region CR without increasing the width of the black matrixes **250a** and **250b**,

the light leakage problem, the color mixture problem and the transmittance decrease problem are prevented.

FIG. 8 is a schematic plane view showing a flat state of a curved LCD device according to a third embodiment of the present invention.

As shown in FIG. 8, a curved LCD device **300** according to the third embodiment of the present invention includes first and second substrates **310** and **320**, which face each other, and a liquid crystal layer (not shown) therebetween. In the first and second substrates **310** and **320**, a central region CR, a first peripheral region BR1 and a second peripheral region BR2, which is positioned between the central region CR and the first peripheral region BR1, are defined.

A plurality of data lines **340a**, **340b** and **340c** are disposed along a vertical direction on the first substrate **310**.

The data line includes first data lines **340a** in the central region CR of the first substrate **310**, second data lines **340b** in the first peripheral region BR1 and third data lines **340c** in the second peripheral region BR2. The first to third data lines **340a**, **340b** and **340c** are spaced apart from each other by the same distance.

Namely, all of the first to third data lines **340a**, **340b** and **340c** have a first distance "d1", and each pixel region P (of FIG. 6), which is defined by the data lines **340a**, **340b** and **340c** and the gate lines, has a first width "w1" (of FIG. 6).

On the second substrate **320**, a black matrix **350a**, **350b** and **350c**, which extends to be parallel to the first to third data lines **340a**, **340b** and **340c** and has an opening in correspondence to the pixel region P, is disposed.

The black matrix includes first black matrixes **350a** in the central region CR, second black matrixes **350b** in the first peripheral region BR1 and third black matrixes **350c** in the second peripheral region BR2. The first black matrixes **350a** have the same distance from each other, while the second and third black matrixes **350b** and **350c** have difference distances from each other.

Namely, the first black matrixes **350a** in the central region CR are spaced apart from each other by a second distance "d2", which is substantially equal to the first distance "d1" between the data lines **340a**, **350b** and **340c**, while the second black matrixes **350b** in the first peripheral region BR1 are spaced apart from each other by a third distance "d3", which is smaller than the first distance "d1" between the data lines **340a**, **340b** and **340c**. In addition, the third black matrixes **350c** in the second peripheral region BR2 are spaced apart from each other by a fourth distance "d4", which is smaller than the second distance "d2" between the first black matrixes **350a** and larger than the third distance "d3" between the second black matrixes **350b**.

Namely, the second and third black matrixes **350b** and **350c** in the first and second peripheral regions BR1 and BR2 are shifted toward the central region CR such that the distance between adjacent third black matrixes **350c** and the distance between adjacent second black matrixes **350b** are decreased from the central region CR to an end of the second substrate **320** with respect to a curvature direction of the second substrate **320**.

In the curved LCD device in FIGS. 6 and 7, the distance between the black matrixes **250a** and **250b** are gradually decreased from the central region CR to the peripheral region BR. On the other hand, in the curved LCD device in FIG. 8, the distance between the black matrixes **350a**, **350b** and **350c** are stepwisely decreased. In other words, in the curved LCD device in FIG. 8, the distance between the black matrixes **350a**, **350b** and **350c** in one of the central region CR, the first peripheral region BR1 and the second peripheral region BR2 is equal to each other.

When the color filter layer **160** (of FIG. 4) including the red, green and blue color filter patterns **162**, **164** and **166** (of FIG. 4) is formed in the opening of the black matrixes **350a**, **350b** and **350c**, the color filter layer **160** in the central region CR has a second width “w2”, which is substantially equal to the first width “w1” of the pixel region P, and the color filter layers in the first and second peripheral regions BR1 and BR2 have a width being smaller than the first width “w1” of the pixel region P.

Namely, the width of the color filter layer between the black matrixes **350a**, **350b** and **350c** is stepwisely decreased from the central region CR to the end of the second substrate **320**. The width of the color filter layer in the second peripheral region BR2 is smaller than the width of the color filter in the central region CR and larger than the width of the color filter layer in the first peripheral region BR1.

When the flat LCD device is curved to provide the curved LCD device **300**, a difference in the arc length generated by the curvature of the curved LCD device **300** is compensated by the shift arrangement of the black matrixes **350b** and **350c** such that a mis-alignment between the black matrixes **350b** and **350c** and the data lines **340b** and **340c** in the peripheral regions BR1 and BR2 is prevented. Accordingly, the light leakage at the periphery of the data lines **340b** and **340c** is not generated.

In addition, since the pixel region P and the color filter layer are accurately matched without the mis-alignment between the black matrixes **350b** and **350c** and the data lines **340b** and **340c**, the color mixture problem by the light in adjacent pixel region P is prevented.

Namely, by shifting the second black matrixes **350b** and **350c** in the peripheral regions BR1 and BR2 into the central region CR without increasing the width of the black matrixes **350a**, **350b** and **350c**, the light leakage problem, the color mixture problem and the transmittance decrease problem are prevented.

With reference to FIG. 9, a shift arrangement of a black matrix in a curved LCD device is explained.

As shown in FIG. 9, in the curved LCD device, the arc length of an upper substrate “SUB1” is different from the arc length of a lower substrate “SUB2” with respect to a pre-determined angle “ θ ”. Namely, a first arc length “L1” of the upper substrate “SUB1” is smaller than a second arc length “L2” of the lower substrate “SUB2” such that the problems, such as the color mixture, the light leakage, and so on, shown in FIG. 5 are generated.

To resolve the above problems, the black matrixes are shifted as shown in FIGS. 6 to 8. For example, the black matrixes are shifted by a half of the difference between the first arc length “L1” of the upper substrate “SUB1” and the second arc length “L2” of the lower substrate “SUB2” to prevent the mis-alignment between the black matrix and the data line.

With reference to FIG. 10, which is a schematic view explaining a shift principle of an upper substrate in a curved LCD device, the shift range is maximized in a $\frac{1}{4}$ point and a $\frac{3}{4}$ point. In FIG. 10, the x axis is a position in the length direction of the substrate, and the y direction is a shift range in micrometer.

Accordingly, the shift of the black matrix for compensating the mis-alignment between the black matrix and the data line is conducted in consideration of the substrate shift principle.

FIG. 11 is a schematic plane view showing a flat state of a curved LCD device according to a fourth embodiment of the present invention.

As shown in FIG. 11, a curved LCD device **400** according to the fourth embodiment of the present invention includes first and second substrates **410** and **420**, which face each other, and a liquid crystal layer (not shown) therebetween. In the first and second substrates **410** and **420**, a central region CR, a first peripheral region BR1 and a second peripheral region BR2, which is positioned between the central region CR and the first peripheral region BR1, are defined.

A plurality of data lines **440a**, **440b** and **440c** are disposed along a vertical direction on the first substrate **410**.

The data line includes first data lines **440a** in the central region CR of the first substrate **410**, second data lines **440b** in the first peripheral region BR1 and third data lines **440c** in the second peripheral region BR2. The first to third data lines **440a**, **440b** and **440c** are spaced apart from each other by the same distance.

Namely, all of the first to third data lines **440a**, **440b** and **440c** have a first distance “d1”, and each pixel region P (of FIG. 6), which is defined by the data lines **440a**, **440b** and **440c** and the gate lines, has a first width “w1” (of FIG. 6).

On the second substrate **420**, a black matrix **450a**, **450b** and **450c**, which extends to be parallel to the first to third data lines **440a**, **440b** and **440c** and has an opening in correspondence to the pixel region P, is disposed.

The black matrix includes first black matrixes **450a** in the central region CR, second black matrixes **450b** in the first peripheral region BR1 and third black matrixes **450c** in the second peripheral region BR2. The distance between the first black matrixes **450a** in the central region CR is substantially equal to the distance between the second black matrixes **450b** in the first peripheral region BR1 and different from the distance between the third black matrixes **450c** in the second peripheral region BR2.

Namely, the first black matrixes **450a** in the central region CR and the second black matrixes **450b** in the first peripheral region BR1 are spaced apart from each other by a second distance “d2”, which is substantially equal to the first distance “d1” between the data lines **450a**, **450b** and **450c**, and the third black matrixes **450c** in the second peripheral region BR2 are spaced apart from each other by a third distance “d3”, which is smaller than the second distance “d2”.

With reference again to FIG. 10, since the substrate of the curved LCD device has a maximum shift range at the regions between the center of the substrate and an end of the substrate, i.e., the $\frac{1}{4}$ and $\frac{3}{4}$ positions, the shift range of the black matrixes **450a**, **450b** and **450c** is maximized at the second peripheral region BR2 between the center of the substrate and the end of the substrate.

Namely, the distance between the black matrixes is decreased from the central region CR to the second peripheral region BR2, and the distance between the black matrixes is increased from the second peripheral region BR2 to the first peripheral region BR1.

In addition, when the color filter layer **160** (of FIG. 4) including the red, green and blue color filter patterns **162**, **164** and **166** (of FIG. 4) is formed in the opening of the black matrixes **450a**, **450b** and **450c**, the color filter layer **160** has a second width “w2”, which is substantially equal to the first width “w1” of the pixel region “P”, in the central region CR and the first peripheral region BR1 and has a width, which is smaller than the first width “w1” of the pixel region, in the second peripheral region BR2 according to a distance variation of the black matrixes **450a**, **450b** and **450c**.

In the curved LCD device, since the mis-alignment between the black matrixes **450b** and **450c** and the data lines **440b** and **440c** is further compensated, the light leakage

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problem, the color mixture problem and the transmittance decrease problem are prevented. In addition, since the black matrixes **450a**, **450b** and **450c** have the same width, there is no decreased of the aperture ratio.

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

What is claimed is:

1. A curved liquid crystal display device, comprising:
first and second substrates facing each other and including
a central region and a first peripheral region;
a plurality of data lines disposed on the first substrate and
being spaced apart from each other, wherein a distance
between adjacent data lines in the central region is the
same as a distance between adjacent data lines in the
first peripheral region;
a plurality of gate lines disposed on the first substrate and
crossing the plurality of data lines;
a pixel electrode disposed on the first substrate;
a common electrode on the first substrate or the second
substrate;
a black matrix disposed on the second substrate and
including first black matrixes in the central region and
second black matrixes in the first peripheral region; and
a liquid crystal layer disposed between the first and
second substrates,
wherein the first black matrixes are spaced apart from
each other by a first distance, and the second black
matrixes are spaced apart from each other by a second
distance being smaller than the first distance,
wherein the first and second substrates further include a
second peripheral region between the central region
and the first peripheral region, and the black matrix
further includes third black matrixes in the second
peripheral region, and
wherein the third black matrixes are spaced apart from
each other by a third distance being smaller than the
first distance and larger than the second distance.
2. The curved liquid crystal display device according to
claim 1, further comprising:
first to third color filters on the second substrate and in the
central region and the first and second peripheral
regions, respectively, wherein the third color filter has
a width being smaller than the first color filter and being
larger than the second color filter.
3. The curved liquid crystal display device according to
claim 1, further comprising:
first and second color filters on the second substrate and
in the central region and the first peripheral region,
respectively, wherein the second color filter has a width
being smaller than the first color filter.
4. A color filter substrate for a curved liquid crystal
display device, comprising:
a substrate including a central region and a first peripheral
region;

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first black matrixes in the central region and spaced apart
from each other by a first distance along a major axis
of the substrate;

second black matrixes in the first peripheral region and
spaced apart from each other by a second distance,
which is smaller than the first distance, along the major
axis of the substrate;

third black matrixes in a second peripheral region
between the central region and the first peripheral
region,

wherein the third black matrixes are spaced apart from
each other by a third distance being smaller than the
first distance and larger than the second distance; and
a color filter layer between the first and second black
matrixes.

5. A curved display device, comprising:
first and second substrates facing each other and including
a central region and a first peripheral region;
a plurality of gate lines and data lines on the first sub-
strate;

first black matrixes in the central region and having a first
distance between the first black matrixes; and
second black matrixes in the first peripheral region and
having a second distance between the second black
matrixes,

wherein the first distance is larger than the second dis-
tance, and

wherein a distance between adjacent data lines in the
central region is the same as a distance between adja-
cent data lines in the first peripheral region;

a second peripheral region between the central region and
the first peripheral region; and

third black matrixes in the second peripheral region and
having a third distance between the third black
matrixes,

wherein the third distance is smaller than the first distance
and larger than the second distance.

6. The curved display device of claim 5, further compris-
ing:

a first color filter in the central region and having a first
width;

a second color filter in the first peripheral region and
having a second width; and

a third color filter in the second peripheral region and
having a third width,

wherein the third width is smaller than the first width and
larger than the second width.

7. The curved display device of claim 5, further compris-
ing:

a first arc length of the second substrate; and

a second arc length of the first substrate,

wherein the first and second black matrixes are shifted by
a half of a difference between the first and second arc
length.

8. The curved display device of claim 7, further compris-
ing a shift range of the first and second black matrixes
configured to maximize in a $\frac{1}{4}$ and $\frac{3}{4}$ point.

* * * * *

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摘要(译)

一种弯曲液晶显示装置，包括彼此面对的第一和第二基板，并包括中心区域和周边区域；多条数据线设置在第一基板上并且彼此间隔开相同的距离；多条栅极线设置在第一基板上并与多条数据线交叉；像素电极设置在第一基板上；第一基板或第二基板上的公共电极；多个黑矩阵设置在第二基板上，中心区域中相邻黑矩阵之间的距离小于周边区域中相邻黑矩阵之间的距离；液晶层设置在第一和第二基板之间。

