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(54) **LIQUID CRYSTAL DISPLAY DEVICE AND METHOD FOR DRIVING A LIQUID CRYSTAL DISPLAY DEVICE**

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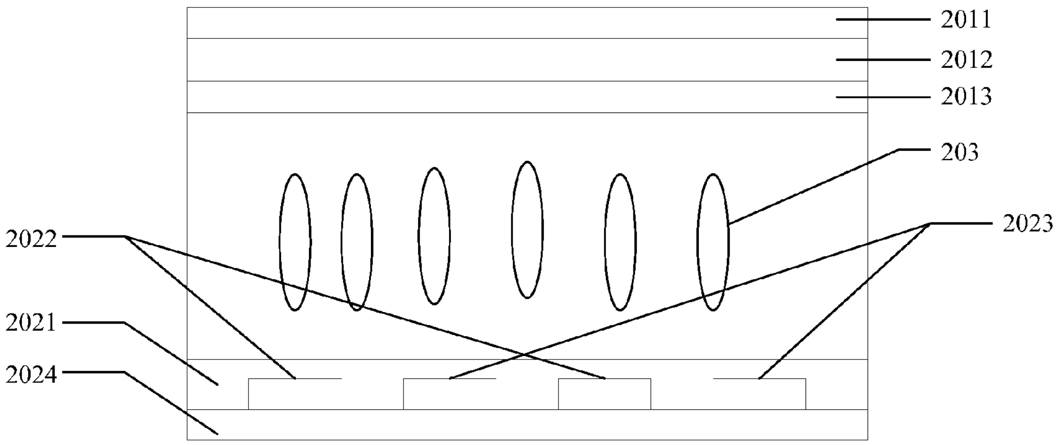
(57) **ABSTRACT**

A liquid crystal display device is disclosed, which has improved transmittance, and which meanwhile can obtain a higher contrast and maintain a lower cost. The device comprises a color filter substrate, an array substrate, and a liquid crystal layer sealed between the color filter substrate and the array substrate. The array substrate comprises a first pixel electrode and a second pixel electrode, the first pixel electrode and the second pixel electrode being arranged at an interval, and applied with AC voltages of equal frequency but opposite phase, respectively. Also, a method for driving the liquid crystal display device is disclosed.



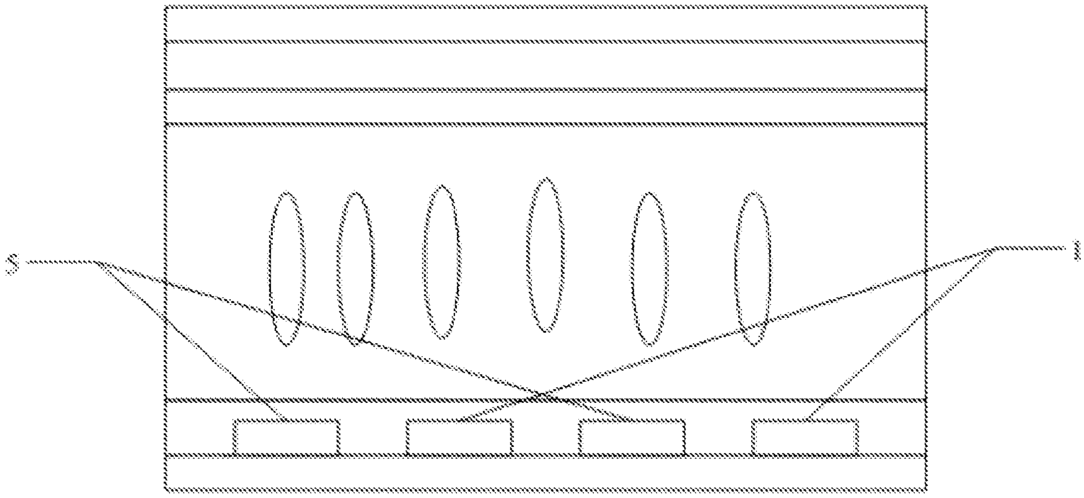



FIG.1

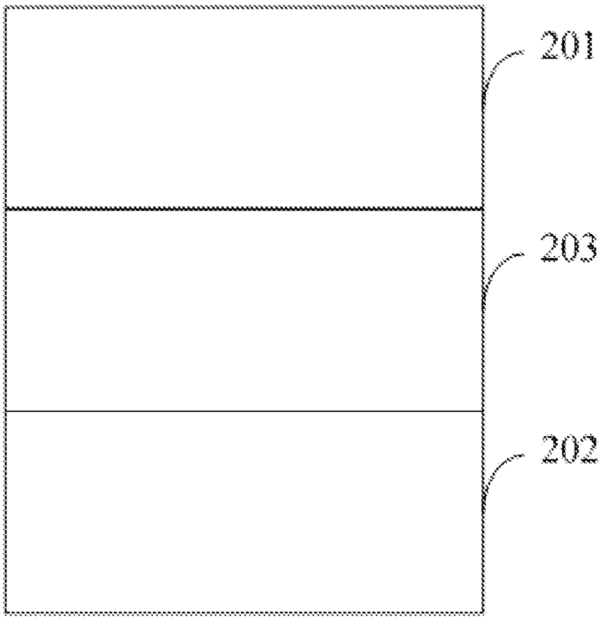



FIG.2

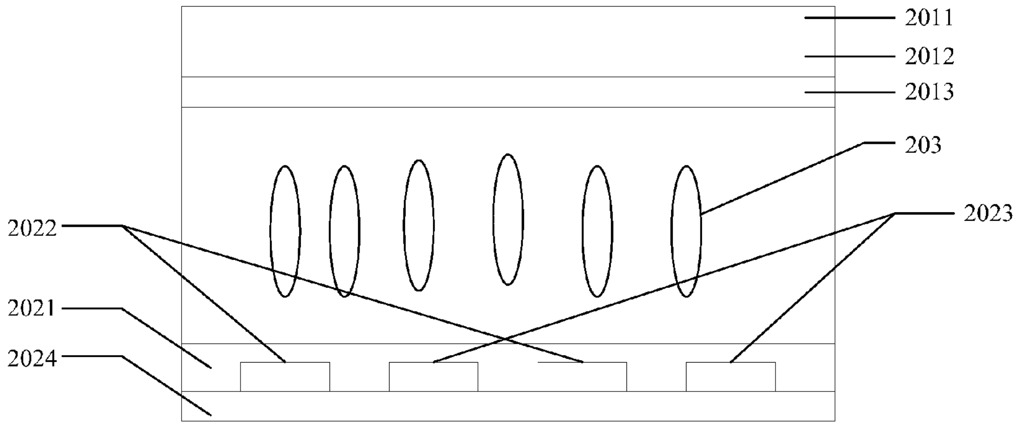

2011
2012
2013
203
2022
2023
2021
2024

FIG.3A

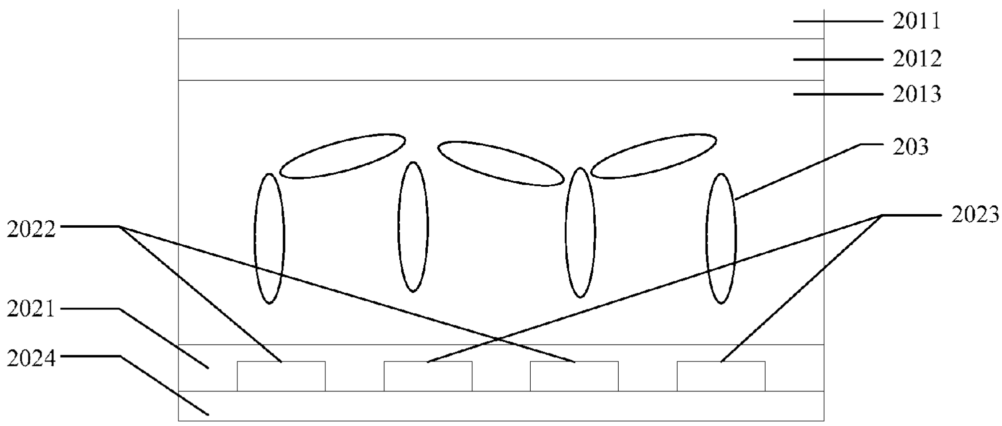

2011
2012
2013
203
2022
2023
2021
2024

FIG.3B

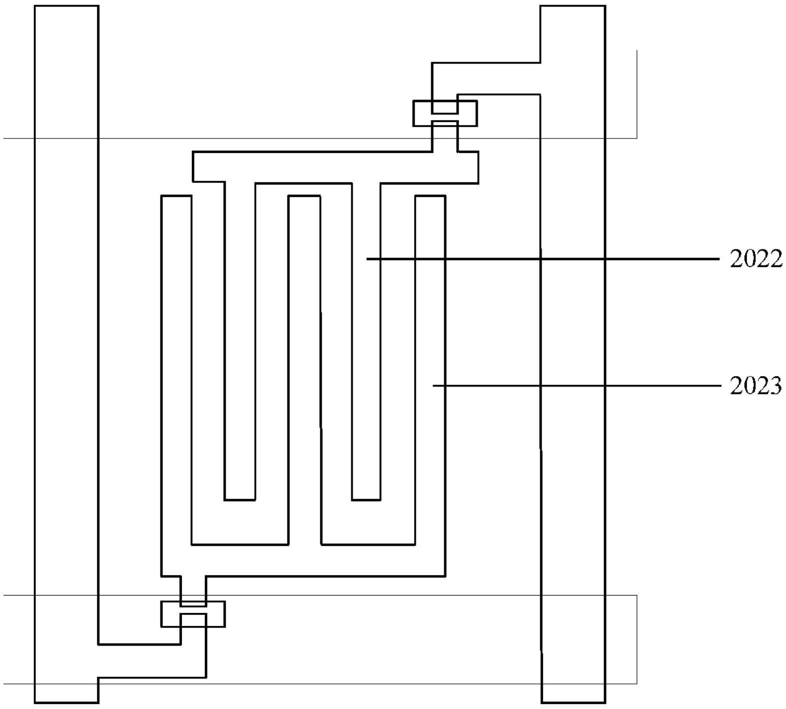



FIG.3C

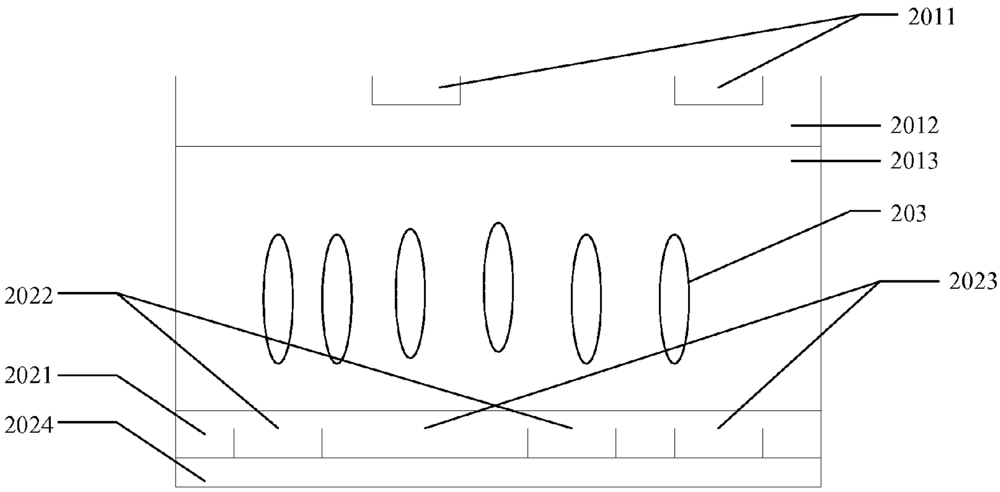



FIG.4

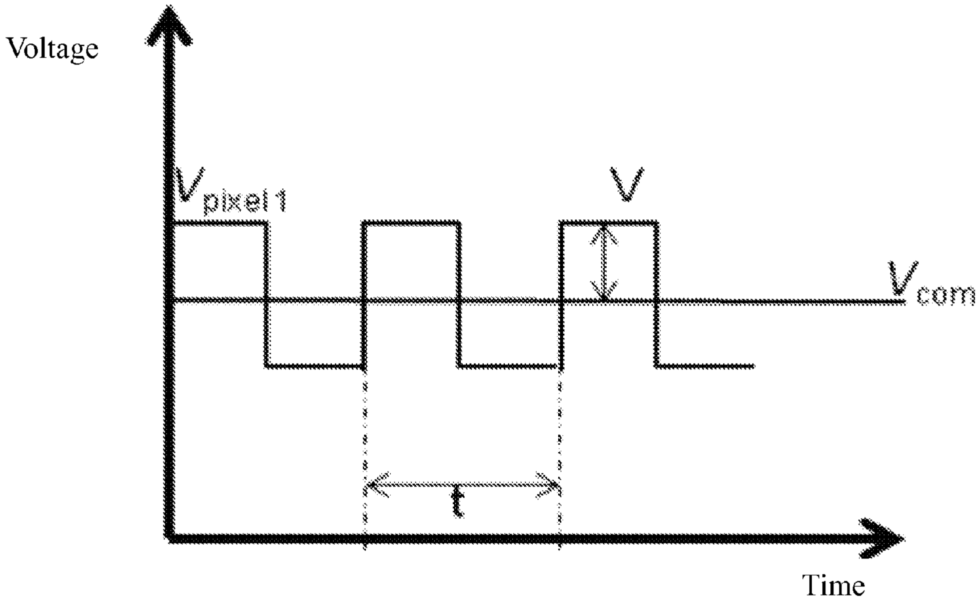



FIG.5A

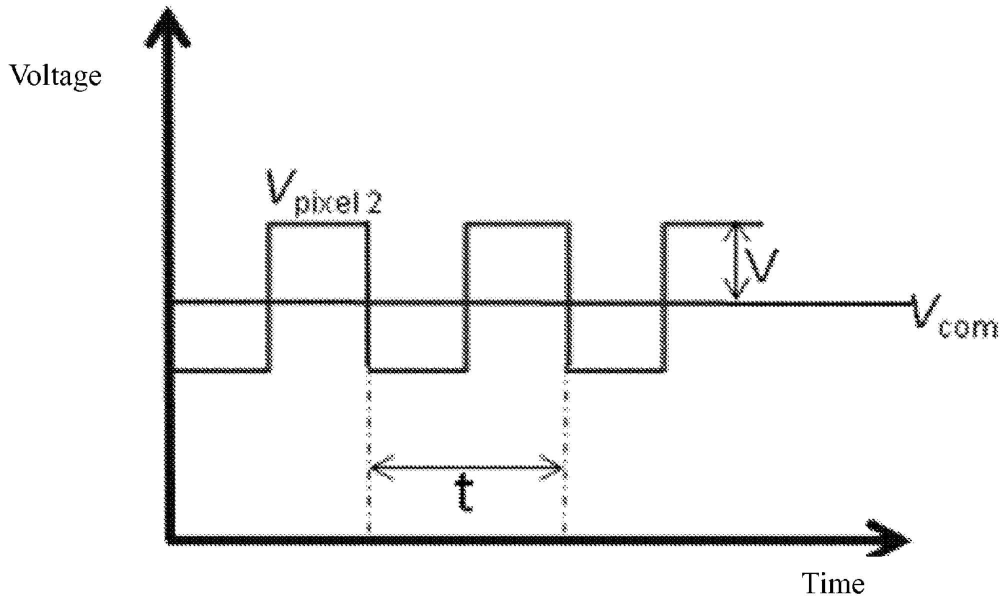



FIG.5B

# LIQUID CRYSTAL DISPLAY DEVICE AND METHOD FOR DRIVING A LIQUID CRYSTAL DISPLAY DEVICE

## TECHNICAL FIELD

**[0001]** The present disclosure relates to a liquid crystal display device and a method for driving a liquid crystal display device.

## BACKGROUND

**[0002]** It is well known that, existing thin film transistor liquid crystal displays (TFT-LCDs) are used in information display devices, such as a portable terminal device's information display window, a notebook computer's image display, and a laptop computer's monitor, etc. TFT-LCDs are the only display devices that fully catch up and exceed cathode ray tube (CRT) displays in general performance such as brightness, contrast, power consumption, lifespan, volume and weight, etc. It has advantages of excellent performance and high degree of automation, etc.

**[0003]** The TFT-LCD technology has been comparatively mature, as the long plagued three major problems, i.e., viewing angle, color saturation and brightness, in connection with an LCD flat panel display have been resolved.

**[0004]** In the prior art, there has been proposed a transverse bend alignment (TBA) mode based on an IPS electrode structure and vertical alignment of liquid crystal. In the TBA mode, since the liquid crystal is positive liquid crystal in vertical alignment, it is possible to obtain a higher contrast and maintain a lower cost. As shown in FIG. **1**, the TBA mode liquid crystal display device comprises adjacent electrodes, which are respectively a pixel electrode **5** and a common electrode **1**. The common electrode **1** is applied with a constant direct-current (DC) voltage, and the electrical potential difference between the common electrode **1** and the pixel electrode **5** is relatively small, and the field intensity of the generated horizontal electric field is therefore relatively weak, which is not beneficial for the liquid crystal molecules to tilt in a horizontal direction, and thus makes the transmittance decreased. Therefore, the TBA mode has a disadvantage of a lower transmittance, which can not meet the needs in some occasions.

## SUMMARY

**[0005]** According to an embodiment of the present disclosure, there is provided a liquid crystal display device, which comprises: a color filter substrate, an array substrate, and a liquid crystal layer sealed between the color filter substrate and the array substrate, wherein the array substrate comprises at least one first pixel electrode and at least one second pixel electrode, and the first pixel electrode and the second pixel electrode are arranged at an interval, and applied with alternating current (AC) voltages of equal frequency but opposite phase, respectively.

**[0006]** Preferably, the AC voltages respectively applied on the first pixel electrode and the second pixel electrode have same amplitudes.

**[0007]** Preferably, the color filter substrate comprises a common electrode.

**[0008]** More preferably, one side of the common electrode facing the array substrate, there is covered with a protective layer.

**[0009]** The liquid crystal layer may comprise positive liquid crystal molecules therein.

**[0010]** The first pixel electrode and the second pixel electrode may be made of a same indium-tin oxide layer through a patterning process.

**[0011]** In some examples, the first pixel electrode and the second pixel electrode may be line-type strip-like electrodes.

**[0012]** The first pixel electrode and the second pixel electrode may employ an indium-tin oxide semiconductor material.

**[0013]** Preferably, the liquid crystal molecules in the liquid crystal layer are in vertical alignment when not supplied with power.

**[0014]** According to an embodiment of the present disclosure, there is also provided a method for driving a liquid crystal display device, which is applied in a liquid crystal display device having a color filter substrate, an array substrate, and a liquid crystal layer sealed between the color filter substrate and the array substrate, wherein the array substrate comprises at least one first pixel electrode and at least one second pixel electrode, the first pixel electrode and the second pixel electrode being arranged at an interval, the method comprising: applying AC voltages of equal frequency but opposite phase to the first pixel electrode and the second pixel electrode on the array substrate, respectively.

**[0015]** Preferably, the AC voltages respectively applied on the first pixel electrode and the second pixel electrode have same amplitudes.

**[0016]** Preferably, under the effect of the positive/negative voltages being applied, the liquid crystal molecules, located at positions where the field intensity in a horizontal direction is greater than in a vertical direction in the liquid crystal layer, are approximately in a horizontal state.

**[0017]** In the liquid crystal display device and the method for driving a liquid crystal display device, according to the embodiments of the present disclosure, the array substrate comprises a first pixel electrode and a second pixel electrode, the first pixel electrode and the second pixel electrode being arranged at an interval, and applied with AC voltages of equal frequency but opposite phase, respectively. This enhances the field intensity of a horizontal electric field, causing the liquid crystal molecules prone to be inclined to a horizontal state, thereby improving the transmittance of the liquid crystal layer.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0018]** FIG. **1** is a specific structural view of a liquid crystal display device in the prior art;

**[0019]** FIG. **2** is a main structural view of a liquid crystal display device in an embodiment of the present disclosure;

**[0020]** FIG. **3**A is a schematic view of a liquid crystal display device in an embodiment of the present disclosure in an "OFF" state;

**[0021]** FIG. **3**B is a schematic view of a liquid crystal display device in an embodiment of the present disclosure in an "ON" state;

**[0022]** FIG. **3**C is a plane schematic view of a pixel in an embodiment of the present disclosure;

**[0023]** FIG. **4** is a specific structural view of a liquid crystal display device in an embodiment of the present disclosure in which a common electrode is a strip-like electrode;

**[0024]** FIG. **5**A is a voltage timing diagram of a first pixel electrode applied with a voltage signal in an embodiment of the present disclosure; and

[0025] FIG. 5B is a voltage timing diagram of a second pixel electrode applied with a voltage signal in an embodiment of the present disclosure.

## DETAILED DESCRIPTION

[0026] A liquid crystal display device in an embodiment of the present disclosure comprises: a color filter substrate, an array substrate, and a liquid crystal layer sealed between the color filter substrate and the array substrate. The array substrate comprises a first pixel electrode and a second pixel electrode. The first pixel electrode and the second pixel electrode are arranged at an interval, and are respectively applied with alternating current (AC) voltages of equal frequency but opposite phase. This enhances the field intensity of the horizontal electric field, causing the liquid crystal molecules prone to be inclined to a horizontal state, thereby improving the transmittance of the liquid crystal layer.

[0027] In some examples, the AC voltages respectively applied on the first pixel electrode and the second pixel electrode may have same amplitudes.

[0028] Referring to FIG. **2**, the liquid crystal display device in this embodiment of the disclosure comprises a color filter substrate **201**, an array substrate **202**, and a liquid crystal layer **203** sealed between the color filter substrate **201** and the array substrate **202**.

[0029] The liquid crystal display device in this embodiment of the disclosure may adopt a PLVA (Positive Liquid crystal Vertical Alignment) mode.

[0030] Referring to FIG. **3**A, it is a schematic view of the device in this embodiment of the disclosure in an "OFF" state, i.e. when power is off. FIG. **3**B is a schematic view of the device in this embodiment of the disclosure in an "ON" state, i.e. when power is on. In this embodiment of the disclosure, the structure of the device is explained with such an example in which the device is placed in a horizontal plane, the color filter substrate **201** is located on the upper side of the device, and the array substrate **202** is located on the lower side of the device. It should be understood that, here the wordings for orientations such as "upper", "lower", etc., are merely for the convenience of understanding, instead of being restrictive. The color filter substrate **201** comprises a common electrode **2011** and a protective layer **2012** covering one side of the common electrode **2011** facing the array substrate **202**; the color filter substrate **201** further comprises a first alignment layer **2013**; and in the device, the alignment layer is divided into two parts, located at the upper and lower sides of the liquid crystal layer **203** respectively. Among the layers, the first alignment layer **2013** at the upper side of the liquid crystal layer **203** is located inside the color filter substrate **201** and covering the protective layer **2012**, while the second alignment layer **2021** at the lower side of the liquid crystal layer **203** is located inside the array substrate **202** and covering the pixel electrodes. FIG. **3**C is a plane schematic view of a pixel in the embodiment of the present disclosure.

[0031] The array substrate **202** comprises: a first pixel electrode **2022**, a second pixel electrode **2023** and the second alignment layer **2021** at the lower side of the liquid crystal layer **203**, as well as a passivation layer **2024** at the lower side of the second alignment layer **2021**.

[0032] The common electrode **2011** is located on the color filter substrate **201**, covering the color filters, and a voltage signal applied to the common electrode **2011** may be a constant DC voltage signal. Moreover, the common electrode **2011** may be made of a transparent ITO (indium-tin oxide semiconductor) material.

[0033] Alternatively, as shown in FIG. **4**, the common electrode **2011** may adopt a strip-like electrode, and thus can increase the transmittance.

[0034] The protective layer **2012** covers the common electrode **2011** and functions to reduce the impact of a vertical electric field, which is generated by the electrical potential difference between the common electrode **2011** and the first and second pixel electrodes **2022**, **2023**, on liquid crystal orientation as much as possible.

[0035] The first alignment layer **2013** at the upper side of the liquid crystal layer **203** is located inside the color filter substrate **201**, covering the protective layer **2012**, while the second alignment layer **2021** at the lower side of the liquid crystal layer **203** is located inside the array substrate **202**, covering the first pixel electrode **2022** and on the second pixel electrode **2023**. The first pixel electrode **2022** and the second pixel electrode **2023** are located on the passivation layer **2024**. The function of both the first alignment layer **2013** and the second alignment layer **2021** is to make liquid crystal molecules orientated homogeneously.

[0036] The liquid crystal layer **203** is located between the first alignment layer **2013** and the second alignment layer **2021**. The liquid crystal in the liquid crystal layer **203** may be negative liquid crystal or positive liquid crystal. Preferably, the liquid crystal in the liquid crystal layer **203** is positive liquid crystal. Positive liquid crystal, unlike negative liquid crystal having a higher viscosity, has a faster response speed and is inexpensive. Because the first pixel electrode **2022** and the second pixel electrode **2023** are made of a same indium-tin oxide layer through a patterning process and covered by the second alignment layer **2021** thereon, the liquid crystal molecules in the liquid crystal layer **203** will been oriented under the effect of an applied horizontal electric field, and inclined to a horizontal arrangement. In this way, the LCD can work to display. However, due to the presence of an electric field between the pixel electrodes and the common electrode **2011**, when the liquid crystal layer **203** is applied with a voltage, there exists not only an electric field in a vertical direction but also an electric field in a horizontal direction. Liquid crystal molecules locating, at positions where the field intensity in a horizontal direction is greater than in a vertical direction, will occur deflecting. But, some liquid crystal molecules, at positions where the field intensity in a horizontal direction is only slightly greater than in a vertical direction, may have a smaller deflection angle. The greater the field intensity in a horizontal direction at a position is, the more the liquid crystal molecules at that position deflect in a horizontal direction and is inclined to a horizontal arrangement. But there may be also a part of the liquid crystal molecules, located at positions where the field intensity in a horizontal direction is equal to or less than in a vertical direction, and this part of the liquid crystal molecules may be not deflected and still maintain their vertically arranged states. Due to limitations of process, the liquid crystal molecules can not reach standard horizontal arrangement, and therefore only a part of the liquid crystal molecules in the liquid crystal layer **203** are deflected close to the horizontal arrangement. In the embodiment of the present disclosure, when the device is in a full black state, i.e., no power is applied, the liquid crystal is in a vertical alignment. In embodiment of the present disclosure, a horizontal direction refers to the direction of an electric field formed between the first pixel electrode **2022** and the second pixel electrode **2023**, while a vertical direction refers to the direction perpendicular to the horizontal direction.

**[0037]** The first pixel electrode **2022** and the second pixel electrode **2023** are covered by a second alignment layer **2021** thereon, and the first pixel electrode **2022** and the second pixel electrode **2023** are arranged at an interval. In the embodiment of the present disclosure, the first pixel electrode **2022** and the second pixel electrode **2023** may be applied with AC voltage signals of equal frequency but opposite phase, respectively, so that the first pixel electrode **2022** and the second pixel electrode **2023**—when power is on—have voltages of opposite polarity at a same moment. For example, at a moment T**1**, the first pixel electrode **2022** may have a positive voltage, and the second pixel electrode **2023** may have a negative voltage. Preferably, the AC voltages may have same amplitudes. As shown in FIG. **5**A, it is a voltage timing diagram of a voltage signal applied to the first pixel electrode **2022** in an embodiment of the present disclosure, in which Vpixel**1** refers to the first pixel electrode **2022**, and Vcom is the voltage signal applied to the common electrode, which may be a DC signal. As shown in FIG. **5**B, it is a voltage timing diagram of a voltage signal applied to the second pixel electrode **2023** in an embodiment of the present disclosure, in which Vpixel**2** refers to the second pixel electrode **2023**. It can be seen that, at a same moment, the first pixel electrode **2022** and the second pixel electrode **2023** have voltages of equal frequency, same amplitude but opposite phase. Under the effect of the voltages applied, the field intensity of the horizontal electric field is stronger, which makes the liquid crystal molecules in the liquid crystal layer **203** more inclined to a horizontal arrangement due to the effect of the electric field, thereby improving the transmittance of the LCD. The first pixel electrode **2022** and the second pixel electrode **2023** may be made of an ITO material.

**[0038]** In the embodiment of the present disclosure, the first pixel electrode **2022** and the second pixel electrode **2023** may be line-type strip-like electrodes, also may be bent strip-like electrodes.

**[0039]** The passivation layer **2024** is located at the lower side of both the first pixel electrode **2022** and the second the pixel electrode **2023**.

**[0040]** Below, a process for liquid crystal displaying in an embodiment of the present disclosure will be introduced.

**[0041]** When no voltage is applied, the liquid crystal molecules rule are regularly and vertically arranged in the liquid crystal layer **203**, and at this time the liquid crystal molecules are not orientated. After power is on, an electric field is generated between the first and second pixel electrodes **2022**, **2023** and the common electrode, forming an electrical potential difference, thereby driving the liquid crystal molecules to deflect. The direction of the electric field at each liquid crystal molecule's position is not entirely consistent with each other. For example, in FIG. **3**A and FIG. **3**B, for some liquid crystal molecules, the positively charged first pixel electrode **2022** is at the left side, and the negatively charged second pixel electrode **2023** is at the right side, and the direction of the electric field is from the first pixel electrode **2022** to the second pixel electrode **2023**, causing these liquid crystal molecules twist to the their right side to horizontal positions; for some others liquid crystal molecules, the negatively charged second pixel electrode **2023** is at the left side, and the positively charged first pixel electrode **2022** is at the right side, and the direction of the electric field is from the first pixel electrode **2022** to the second pixel electrode **2023**, causing these liquid crystal molecules to twist to their the left side to horizontal positions. Under different driving voltages, the liquid crystal layer **203** will exhibit different transmittances; the greater the value of the applied voltage is, the more the liquid crystal molecules in the liquid crystal layer **203** are close to a horizontal arrangement, and therefore the higher the transmittance occurs. However, the value of the applied voltage can not be too high, in order to prevent burnout of the device.

**[0042]** The liquid crystal display device in the embodiments of the present disclosure comprises: a color filter substrate, an array substrate, and a liquid crystal layer sealed between the color filter substrate and the array substrate; wherein, the array substrate comprises a first pixel electrode and a second pixel electrode, the first pixel electrode and the second pixel electrode being arranged at an interval, and applied with AC voltages of equal frequency but opposite phase, respectively. This enhances the field intensity of the horizontal electric field, causing the liquid crystal molecules prone to be inclined to a horizontal state (because an absolutely horizontal state can not be achieved in process, and there may be some liquid crystal molecules still in a vertical state, it is only possible to be more approximate to a horizontal state), thereby improving the transmittance of the liquid crystal layer. Preferably, the AC voltages respectively applied on the first pixel electrode and the second pixel electrode have same amplitudes. With positive liquid crystal molecules, low viscosity and fast response are achieved, and the device is inexpensive. Because the liquid crystal is in a vertical alignment, the alignment film rubbing process is not required, reducing dark-state light leakage, thus achieving a high contrast. Moreover, the common electrode may adopt a strip-like electrode, in order to improve transmittance, lower power consumption, and make smaller the impact of the electric field, which is generated by an electrical potential difference between the common electrode and the first pixel electrode **2022** or the second pixel electrode **2023**, on the orientation of liquid crystal molecules.

**[0043]** Obviously, various modifications and variations to the present disclosure can be made by the skilled in the art, without departing from the spirit and scope of the present disclosure. Thus, if those modifications and variations of the present disclosure are within the scope of the claims and their equivalents of the present disclosure, the present disclosure is also intended to encompass these variations and modifications.

**1**. A liquid crystal display device, comprising:

a color filter substrate, an array substrate, and a liquid crystal layer sealed between the color filter substrate and the array substrate;

wherein the array substrate comprises at least one first pixel electrode and at least one second pixel electrode, and the first pixel electrode and the second pixel electrode are arranged at an interval and applied with AC voltages of equal frequency but opposite phase, respectively.

**2**. The device according to claim **1**, wherein the AC voltages respectively applied on the first pixel electrode and the second pixel electrode have same amplitudes.

**3**. The device according to claim **1** wherein the color filter substrate comprises a common electrode.

**4**. The device according to claim **3**, wherein one side of the common electrode facing the array substrate is covered with a protective layer.

**5**. The device according to claim **1**, wherein the liquid crystal layer comprises positive liquid crystal molecules therein.

**6**. The device according to claim **1**, wherein the first pixel electrode and the second pixel electrode are made of a same indium-tin oxide layer through a patterning process.

**7**. The device according to claim **1**, wherein the first pixel electrode and the second pixel electrode are line-type strip-like electrodes.

**8**. The device according to claim **1**, wherein the first pixel electrode and the second pixel electrode employ an indium-tin oxide semiconductor material.

**9**. The device according to claim **1**, wherein the liquid crystal molecules in the liquid crystal layer are in a vertical alignment when not supplied with power.

**10**. A method for driving a liquid crystal display device, applied in a liquid crystal display device having a color filter substrate, an array substrate, and a liquid crystal layer sealed between the color filter substrate and the array substrate, wherein the array substrate comprises at least one first pixel electrode and at least one second pixel electrode, the first pixel electrode and the second pixel electrode being arranged at an interval, the method comprising: applying AC voltages of equal frequency but opposite phase to the first pixel electrode and the second pixel electrode on the array substrate, respectively.

**11**. The method according to claim **10**, wherein the AC voltages respectively applied on the first pixel electrode and the second pixel electrode have same amplitudes.

**12**. The method according to claim **10**, wherein under an effect of the positive/negative voltages being applied, the liquid crystal molecules, located at positions where a field intensity in a horizontal direction is greater than in a vertical direction in the liquid crystal layer, are approximately in a horizontal state.

**13**. The device according to claim **1**, wherein the color filter substrate comprises a common electrode, and one side of the common electrode facing the array substrate is covered with a protective layer.

**14**. The device according to claim **6**, wherein the first pixel electrode and the second pixel electrode are line-type strip-like electrodes.

**15**. The device according to claim **5**, wherein the liquid crystal molecules in the liquid crystal layer are in a vertical alignment when not supplied with power.

**16**. The method according to claim **11**, wherein under an effect of the positive/negative voltages being applied, the liquid crystal molecules, located at positions where a field intensity in a horizontal direction is greater than in a vertical direction in the liquid crystal layer, are approximately in a horizontal state.

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| 专利名称(译) | 液晶显示装置和用于驱动液晶显示装置的方法 | | |
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摘要(译)

本发明公开了一种液晶显示装置，其具有改善的透射率，同时可以获得更高的对比度并保持较低的成本。该装置包括滤色器基板，阵列基板和密封在滤色器基板和阵列基板之间的液晶层。阵列基板包括第一像素电极和第二像素电极，第一像素电极和第二像素电极以一定间隔排列，并分别施加相同频率但相位相反的交流电压。此外，公开了一种用于驱动液晶显示装置的方法。