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(54) TRANSFLECTIVE LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF FABRICATING THE SAME

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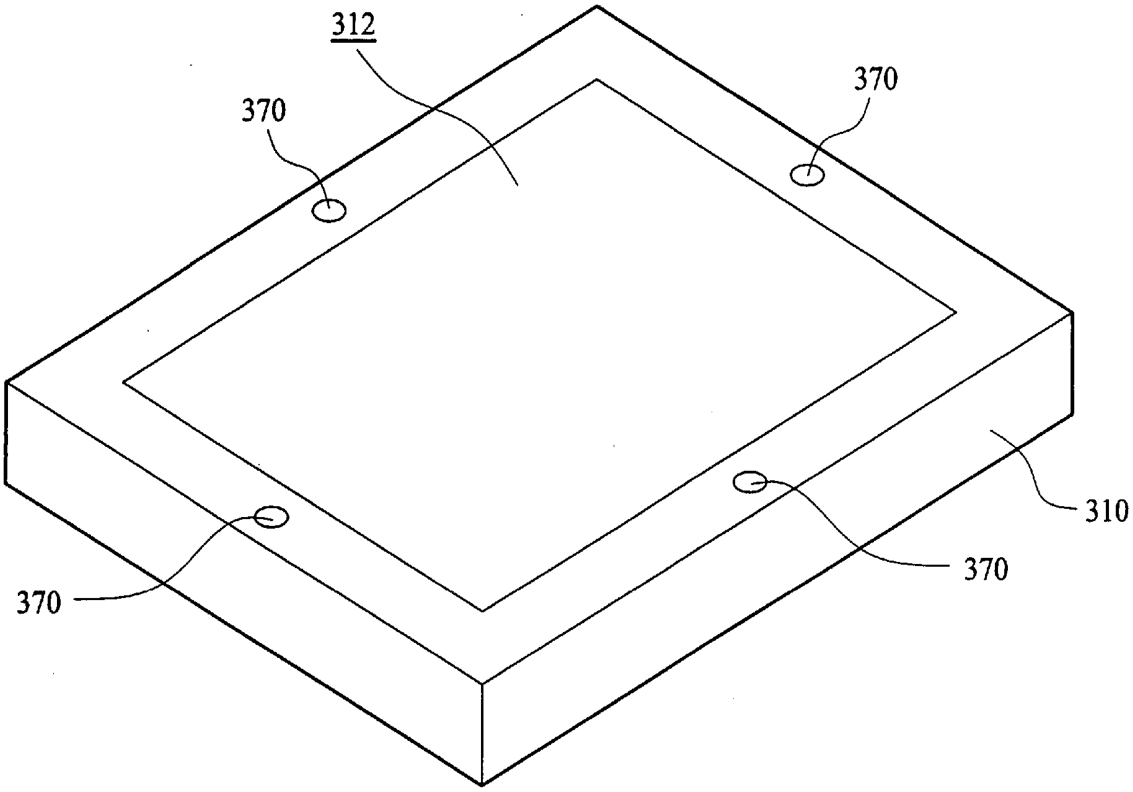
(57) **ABSTRACT**

A transflective liquid crystal display device. A first substrate having viewing and peripheral areas is provided. The viewing area comprises transmissive and reflective regions. A backlight device is disposed under the first substrate, used to provide a backlight passing through the transmissive region. A power management controller connects the backlight device to control an intensity of the backlight. At least one photodetector is formed on the first substrate in the peripheral area, wherein the photodetector detects an intensity of ambient light above the first substrate, and then provides a corresponding signal to the power management controller to control the intensity of the backlight. According to the invention, the intensity of the backlight automatically becomes greater when the intensity of the ambient light becomes lower, and the intensity of the backlight automatically becomes lower when the intensity of the ambient light becomes greater.



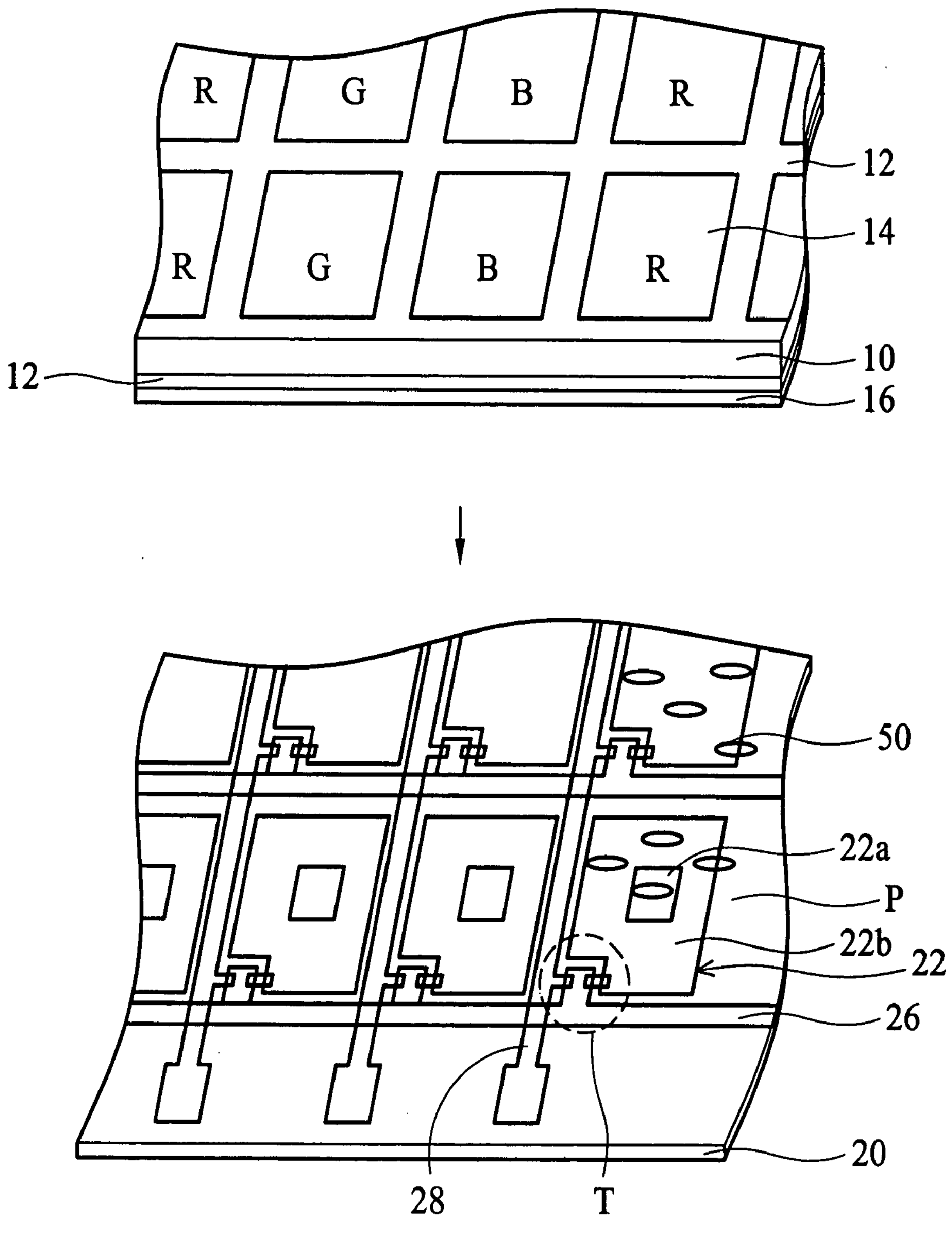


FIG. 1 (PRIOR ART)

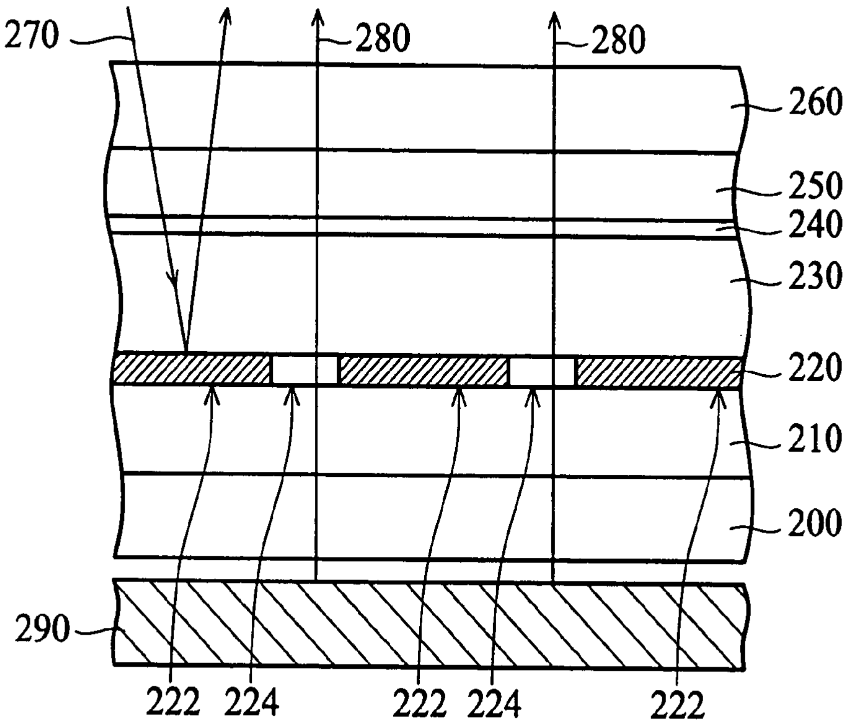


FIG. 2 (PRIOR ART)

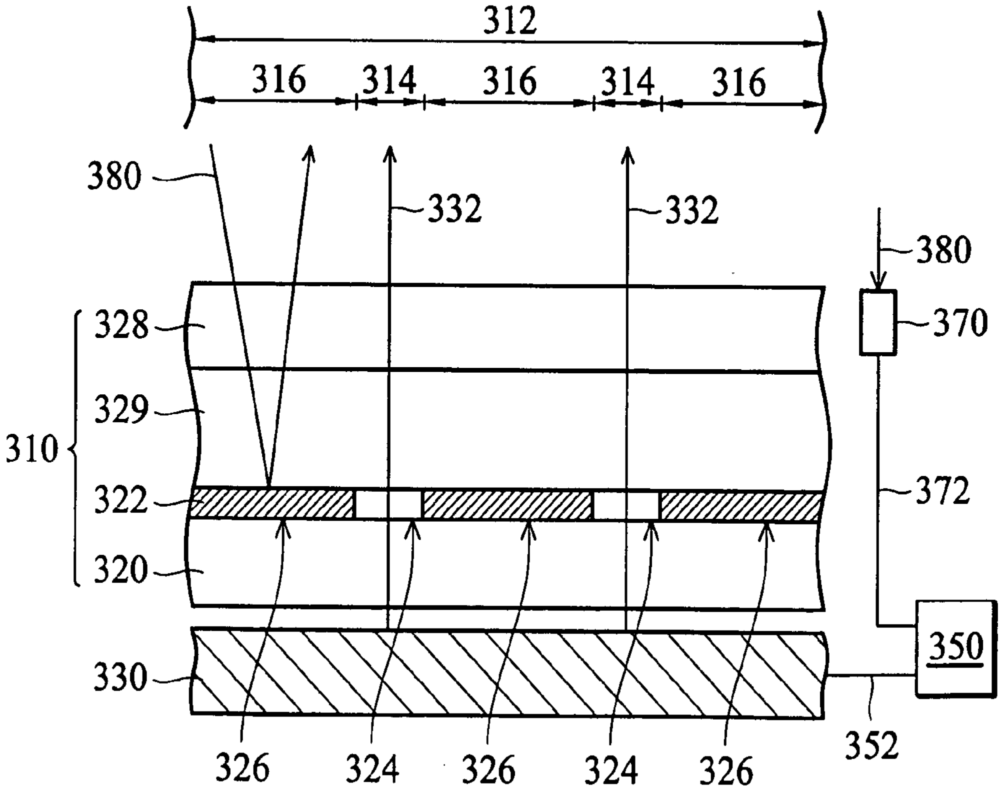


FIG. 3

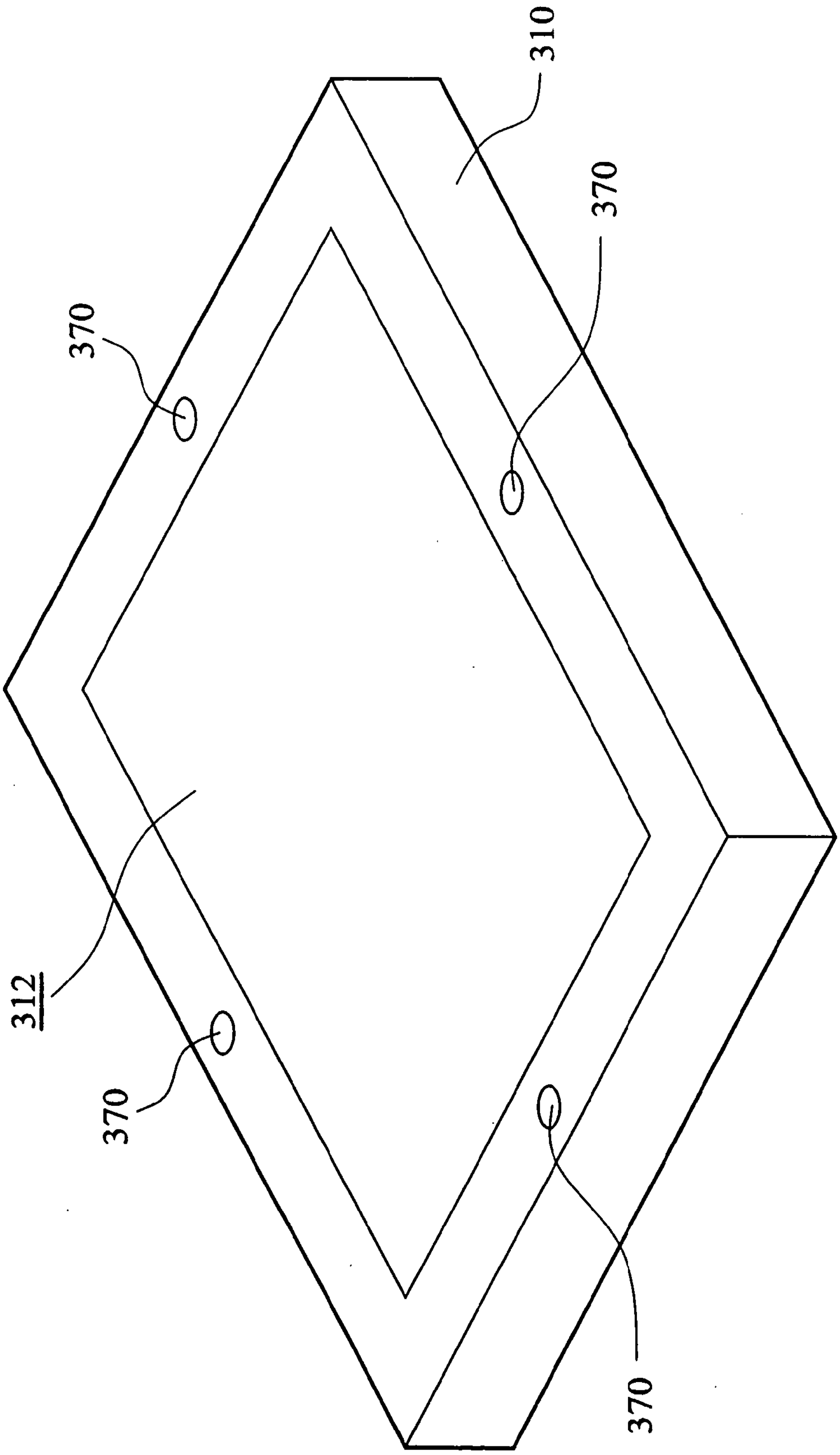


FIG. 4

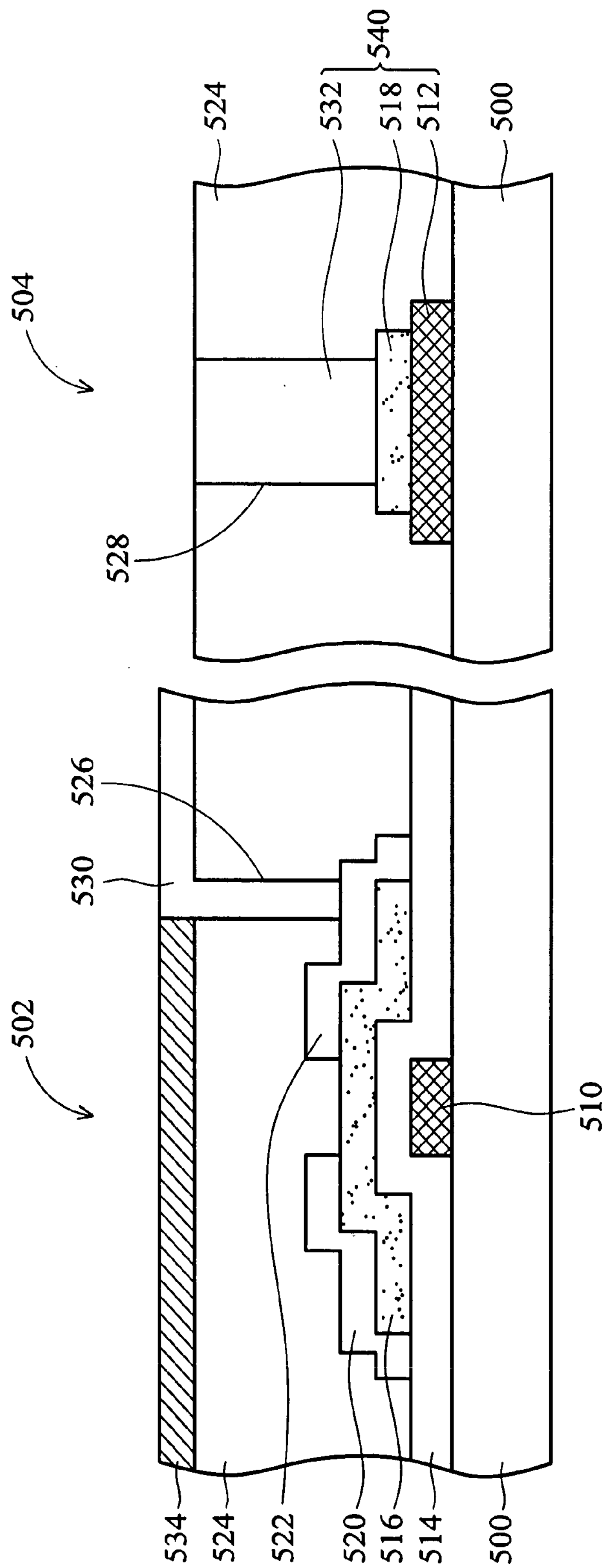


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FIG. 5

TRANSFLECTIVE LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF FABRICATING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a transflective liquid crystal display device, and more particularly, to self adjustment of display brightness according to ambient lighting in a transflective liquid crystal display device.

[0003] 2. Description of the Related Art

[0004] Liquid crystal display (LCD) devices are widely used as displays in devices, such as a portable televisions and notebook computers. Liquid crystal display devices are classified into two types. One is a transmissive type liquid crystal display device using a backlight as a light source, and another is the reflective type liquid crystal display device using an external light source, such as sunlight or an indoor lamp. It is difficult to decrease the weight, the volume, and the power consumption of the transmissive type LCD due to the power required by the backlight component. The reflective type LCD has the advantage of not requiring a backlight component, but it cannot operate without an external light source.

[0005] In order to overcome the drawbacks of these two types of LCDs, a transflective LCD device which can operate as both a reflective and transmissive type LCD is disclosed. The transflective LCD device has a reflective electrode in a pixel region, wherein the reflective electrode has a transmissive portion. Thus, the transflective LCD device consumes less than a conventional transmissive type LCD device because a backlight component is not used when sufficient ambient light is present. Further, in comparison with the reflective type LCD device, the transflective LCD device has the advantage of operating as a transmissive type LCD device using a backlight when no external light is available.

[0006] **FIG. 1** is an exploded perspective view illustrating a typical transflective LCD device. The transflective LCD device includes upper and lower substrates **10** and **20** opposite to each other, and a liquid crystal layer **50** interposed therebetween. The upper substrate **10** is called a color filter substrate and the lower substrate **20** is called an array substrate. In the upper substrate **10**, on a surface opposing the lower substrate **20**, a black matrix **12** and a color filter layer **14** including a plurality of red (R), green (G) and blue (B) color filters are formed. That is, the black matrix **12** surrounds each color filter, in the shape of an array matrix. Further on the upper substrate **10**, a common electrode **16** is formed to cover the color filter layer **14** and the black matrix **12**.

[0007] In the lower substrate **20**, on a surface opposing the upper substrate **20**, a TFT "T" as a switching device is formed in shape of an array matrix corresponding to the color filter layer **14**. In addition, a plurality of crossing gate and data lines **26** and **28** are positioned such that each TFT is located near each cross point of the gate and data lines **26** and **28**. Further on the lower substrate **20**, a plurality of pixel regions (P) are defined by the gate and data lines **26** and **28**. Each pixel region P has a pixel electrode **22** comprising a transparent portion **22***a* and an opaque portion **22***b*. The transparent portion **22***a* is made of a transparent conductive material, such as ITO (indium tin oxide) or IZO (indium zinc oxide), and the opaque portion **22***b* is made of a metal having high reflectivity, such as Al (aluminum).

[0008] **FIG. 2** is a sectional view of a conventional transflective LCD device, which helps to illustrate the operation of such devices. As shown in **FIG. 2**, the conventional transflective LCD device includes a lower substrate **200**, an upper substrate **260** and an interposed liquid crystal layer **230**. The upper substrate **260** has a common electrode **240** and a color filter **250** formed thereon. The lower substrate **200** has an insulating layer **210** and a pixel electrode **220** formed thereon, wherein the pixel electrode **220** has an opaque portion **222** and a transparent portion **224**. The opaque portion **222** of the pixel electrode **220** can be an aluminum layer, and the transparent portion **224** of the pixel electrode **220** can be an ITO (indium tin oxide) layer. The opaque portion **222** reflects ambient light **270**, while the transparent portion **224** transmits light **280** from a backlight device **290** disposed at the exterior side of the lower substrate **200**. The liquid crystal layer **230** is interposed between the lower and upper substrates **200** and **260**. Thus, the transflective LCD device is operable in both reflective and transmissive modes.

[0009] In order to obtain a stable display quality of the transflective LCD, it is desirable for the display brightness to also change when the ambient light of the environment changes. For example, when the ambient light becomes darker, the backlight has to become brighter to maintain the determined total display brightness. Contrarily, when the ambient light becomes brighter, the backlight intensity is decreased to maintain the determined total display brightness and reduce power consumption. Nevertheless, current transflective LCDs require manual adjustment to change the intensity of the backlight. This method of adjustment and is very inconvenient for users.

[0010] In U.S. Pat. No. 5,157,525, Eaton et al disclose an LCD device employing a photodetector to compensate for variation in the characteristics of the liquid crystal. The LCD uses a photodetector to detect the transmissivity of liquid crystal elements under the ON and OFF states. According to the signal from the photodetector, the voltage level of the pixel driving element can be adjusted to obtain an optimum contrast and brightness. Though effective, this method, nevertheless, does not disclose how to obtain optimum display brightness when the ambient light of the environment changes.

SUMMARY OF THE INVENTION

[0011] The object of the present invention is to provide a smart transflective liquid crystal display device and its fabricating method.

[0012] Another object of the present invention is to provide a transflective liquid crystal display device, which can self-adjust a backlight intensity to maintain optimum (or stable) display brightness whether the ambient light of the environment changes.

[0013] In order to achieve these objects, the present invention provides a transflective liquid crystal display device. A display panel having a viewing area is provided, wherein the viewing area comprises a transmissive region and a reflective region. A backlight device is disposed under the display panel, wherein the backlight device provides a backlight passing through the transmissive region. A power management controller is connected to the backlight device, wherein the power management controller controls the intensity of the backlight. At least one photodetector is located on the display panel outside the viewing area, wherein the photodetector detects the intensity of ambient light around the display panel, and then provides a corresponding signal to the power management controller to control the intensity of the backlight. The intensity of the backlight automatically becomes greater when the intensity of the ambient light becomes lower, and the intensity of the backlight automatically becomes lower when the intensity of the ambient light becomes greater, based on a corresponding signal of the power management controller.

[0014] In order to achieve these objects, the present invention additionally provides a method of manufacturing a transflective liquid crystal display device. A first substrate having a viewing area and a peripheral area is provided. A metal layer is formed on part of the first substrate in both the viewing and the peripheral areas, wherein the metal layer in the viewing area serves as a gate. A gate insulating layer is formed on the gate. A semiconductor layer is formed on the gate and the metal layer in the peripheral area. A source electrode and a drain electrode are formed on part of the semiconductor layer on the gate insulating layer. An insulating layer is formed over the first substrate. A first opening and a second opening are formed to penetrate the insulating layer, wherein the first opening exposes the drain electrode and the second opening exposes the semiconductor layer in the peripheral area. A transparent conductive layer is formed in the second opening and the first opening, and the transparent conductive layer extends to part of the insulating layer. A reflective layer is formed on part of the insulating layer. A backlight device is disposed under the first substrate, providing light which passes through the opening in the transparent conductive layer to the exposed underlying insulating layer. A power management controller is connected to the backlight device, wherein the power management controller controls the intensity of the backlight. A photodetector consists of the metal layer, the semiconductor layer and the transparent conductive layer in the peripheral area. The photodetector detects an intensity of ambient light above the first substrate, and then provides a corresponding signal to the power management controller to control the intensity of the backlight. The intensity of the backlight automatically becomes greater when the intensity of the ambient light becomes lower, and the intensity of the backlight automatically becomes lower when the intensity of the ambient light becomes greater, based on a corresponding signal of the power management controller.

[0015] The present invention improves on the prior art in that the transflective LCD device has at least one photodetector located on the LCD panel. The photodetector senses ambient lighting conditions above the first substrate, and then provides a corresponding signal to the power management controller to control the intensity of the backlight. Thus, the total amount of reflected and transmitted light can be optimally maintained. In addition, the photodetector can be simultaneously fabricated with the TFT. The transflective LCD device of the present invention can self-adjust the backlight intensity to provide optimum (or stable) display based on the availability and intensity ambient light, simplifying use thereof and ameliorating the disadvantages of the prior art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The present invention can be more fully understood by reading the subsequent detailed description in conjunction with the examples and references made to the accompanying drawings, wherein:

[0017] **FIG. 1** is an exploded perspective view illustrating a typical transflective LCD device;

[0018] **FIG. 2** is a sectional view of a transflective LCD device according to the prior art, illustrating the operation thereof;

[0019] **FIG. 3** is a sectional view according to the present invention;

[0020] **FIG. 4** is a topographical view of the display panel showing the placement of the photodetectors of the preferred embodiment of the present invention; and

[0021] **FIG. 5** is a sectional view illustrating simultaneous fabrication of the photodetector and the TFT according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0022] Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

[0023] **FIG. 3** is a sectional view according to the present invention. **FIG. 4** is a topographical view of the display panel showing the placement of the photodetectors of the preferred embodiment of the present invention.

[0024] In **FIGS. 3 and 4**, the smart transflective LCD device of the present invention comprises a display panel **310**, a backlight source (device) **330**, a power management controller **350** and at least one photodetector **370**.

[0025] The display panel **310** has a viewing area **312**, wherein the viewing area **312** further comprises a transmissive region **314** and a reflective region **316**.

[0026] As a demonstrative example, a structure of the display panel **310** is described herein, but is not intended to limit the present invention. In **FIG. 3**, a first substrate **320**, serving as a lower substrate, is provided above the backlight device **330**. The first substrate **320** can be a glass substrate comprising a thin film transistor (TFT) array (not shown). A pixel electrode **322** is formed on the first substrate **320**, wherein the pixel electrode **322** has a transparent portion **324** and an opaque portion **326**. The transparent portion **324** of the pixel electrode **322** is located in the transmissive region **314**, and the opaque portion **326** of the pixel electrode **322** is located in the reflective region **316**. The transparent portion **324** of the pixel electrode **322** can be an ITO (indium tin oxide) or IZO (indium zinc oxide) layer. The opaque portion **326** of the pixel electrode **322** can be an aluminum or silver layer. A second substrate **328**, serving as an upper substrate, is opposite the first substrate **320**. The second substrate **328** can be a glass substrate comprising a color filter (not shown) formed thereon. Then, liquid crystal molecules fill a space between the first substrate **320** and the second substrate **328** to form a liquid crystal layer **329** therebetween. The display panel **310** is thus obtained.

[0027] The backlight source **330** is disposed under the first substrate **320** and provides a backlight **332** passing through the transmissive region **314** of the display panel **310**. The backlight source **330** comprises a light emitting device, such as a cold cathode fluorescent tube (CCFL) or a light emitting diode (LED).

[0028] The power management controller **350** is connected to the backlight device by means of the control line **352** (e.g. an electric wire). The power management controller **350** controls the intensity of the backlight **332** by controlling power output.

[0029] The photodetector(s) **370** is located on the display panel **310** outside the viewing area **312**. The photodetector **370** detects the intensity of ambient light **380** around the display panel **310**, and then provides a corresponding signal to the power management controller **350** by means of a signal line **371** to control the intensity of the backlight **332**. The photodetector **370** can be a photosensitive resistor device or a photodiode device.

[0030] Referring to **FIG. 4**, there is shown the transflective LCD display panel **310** of the preferred embodiment of the present invention. The display panel **310** includes the viewing area **312**, and in the preferred embodiment, at least four photodetectors **370** are placed at the middle edge of the display panel **310**. The reason is that the positions are the nearest points to the center of the viewing area **312** at each edge.

[0031] An operational example is illustrated hereinafter. When the photodetector **370** senses a higher intensity ambient light above the display panel **310**, the photodetector **370** provides a first corresponding signal to the power management controller **350**. Based on the first corresponding signal, the power management controller **350** will automatically decrease power output to the backlight device **330**, thereby dimming the backlight **332**. When the photodetector **370** senses less intense ambient light above the display panel **310**, the photodetector **370** provides a second corresponding signal to the power management controller **350**. Based on the second corresponding signal, the power management controller **350** will automatically increase power output to the backlight device **330**, thereby brightening the backlight **332**.

[0032] As is apparent from the above description, The transflective LCD device of the present invention can self-adjust the backlight intensity to provide optimum (or stable) display based on the availability and intensity ambient light. That is, the total amount of reflected and transmitted light can be maintained at a desired level, thereby achieving self-adjusting display brightness, and reducing power consumption.

[0033] **FIG. 5** is a sectional view illustrating simultaneous fabrication of photodetector and the TFT, according to an alternative embodiment of the present invention.

[0034] A lower substrate **500** having a predetermined viewing area **502** (or an interior area) and a predetermined peripheral area **504** is provided. The lower substrate **500** can be a glass substrate.

[0035] A metal layer (**510/512**) is next formed on part of the lower substrate **500** in both the viewing and the peripheral areas **502, 504**. The metal layer **510** in the viewing area **502** serves as a gate **510**, and the metal layer **512** in the peripheral area **504** serves as an anode **512** and a light shield **512**. The metal layer (**510/512**) can be an Al layer formed by sputtering.

[0036] A gate insulating layer **514** is formed on the gate **510** and part of the lower substrate **500**. The gate insulating layer **514** can be a SiO_2 layer formed by deposition.

[0037] Then, a semiconductor layer (**516/518**) is formed on part of the gate insulating layer **514** and the anode **512**. The semiconductor layer **516** on the gate insulating layer **514** serves as a channel layer **516**, and the semiconductor layer **518** on the anode **512** serves as a photosensitive layer **518**. The semiconductor layer (**516/518**) can be an amorphous silicon layer. It should be noted that the channel layer **516** and the photosensitive layer **518** can be formed in separate steps. That is, the material of the channel layer **516** can be different from that of the photosensitive layer **518**. For example, the channel layer **516** is amorphous silicon and the photosensitive layer **518** is Cadmium Sulfide (CdS) photosensitive material.

[0038] A source electrode **520** and a drain electrode **522** are then formed on part of the channel layer **516** on the gate insulating layer **514**. The source electrode **520** and the drain electrode **522** can be metal layers, such as Al.

[0039] Next, a transparent insulating layer **524** is blanketly formed over the lower substrate **500**. The transparent insulating layer **524** can be a SiO_2 or SiN layer.

[0040] Then, a first opening **526** and a second opening **528** penetrating the insulating layer **524** is formed. The first opening **526** exposes the drain electrode **522** and the second opening **528** exposes the photosensitive layer **518** in the peripheral area **504**.

[0041] In **FIG. 5**, the first opening **526** and the second opening **528** are filled with transparent conductive material to form a transparent portion **530** of a pixel electrode in the viewing area **502** and a cathode **532** in the peripheral area **504**. The transparent portion **530** of a pixel electrode also extends to part of the insulating layer **524**. The transparent conductive material can be ITO (indium tin oxide) or IZO (indium zinc oxide).

[0042] Next, a reflective layer **534** is formed on part of the insulating layer **524**. The reflective layer **534** can be an aluminum layer or silver layer. The reflective layer **534** serves as an opaque portion **534** of the pixel electrode.

[0043] It should be noted that a photodetector **540** comprises the anode **512**, the photosensitive layer **518** and the cathode **532** in the peripheral area **504**.

[0044] Moreover, as is known in the conventional LCD process and similar to the illustration of **FIG. 3**, a second substrate (not shown) opposite the first substrate **500** is provided. Liquid crystal molecules fill a space between the first substrate **500** and the second substrate (not shown) to form a liquid crystal layer (not shown). In order to avoid obscuring aspects of the present invention, the detailed processes are not described again here.

[0045] Thus, the present invention provides a transflective LCD device having photodetectors integrated therein. The photodetector senses ambient lighting conditions above the first substrate, and then provides a corresponding signal to the power management controller to control the intensity of the backlight. Thus, the total amount of reflected and transmitted light can be maintained at a desired level. In addition, the photodetector can be simultaneously fabricated with the TFT. The transflective LCD device of the present invention can self-adjust the backlight intensity to provide optimum (or stable) display based on the availability and intensity ambient light, simplifying use thereof and ameliorating the disadvantages of the prior art.

[0046] Finally, while the invention has been described by way of example and in terms of the above, it is to be understood that the invention is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements as would be apparent to those skilled in the art. Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

What is claimed is:

1. A transflective liquid crystal display device, comprising:

a display panel having a viewing area, wherein the viewing area comprises a transmissive region and a reflective region;

a backlight device disposed under the display panel, wherein the backlight device provides a backlight passing through the transmissive region;

a power management controller connected with the backlight device, wherein the power management controller controls an intensity of the backlight; and

at least one photodetector located on the display panel outside the viewing area, wherein the photodetector detects an intensity of ambient light around the display panel, and then provides a corresponding signal to the power management controller to control the intensity of the backlight;

wherein, by the power management controller based on the corresponding signal, the intensity of the backlight automatically becomes greater when the intensity of the ambient light becomes lower, and the intensity of the backlight automatically becomes lower when the intensity of the ambient light becomes greater.

2. The transflective LCD device according to claim 1, wherein the display panel comprises:

a first substrate located above the backlight device;

a pixel electrode having a transparent portion and an opaque portion formed on the first substrate, wherein the transparent portion of the pixel electrode is in the transmissive region and the opaque portion of the pixel electrode is in the reflective region;

a second substrate opposite the first substrate; and

a liquid crystal layer interposed between the first and the second substrates.

3. The transflective LCD device according to claim 1, wherein the backlight device comprises a cold cathode fluorescent tube (CCFL) or a light emitting diode (LED).

4. The transflective LCD device according to claim 1, wherein the photodetector is a photosensitive resistor or a photodiode.

5. The transflective LCD device according to claim 2, wherein the first substrate is a glass substrate.

6. The transflective LCD device according to claim 2, wherein the second substrate is a glass substrate.

7. The transflective LCD device according to claim 2, wherein the transparent portion of the pixel electrode is an ITO (indium tin oxide) layer or an IZO (indium zinc oxide) layer.

8. The transflective LCD device according to claim 2, wherein the opaque portion of the pixel electrode is an aluminum layer or a silver layer.

9. A method of fabricating a transflective liquid crystal display device, comprising the steps of:

providing a first substrate having a viewing area and a peripheral area, wherein the viewing area comprises a transmissive region and a reflective region;

disposing a backlight device under the first substrate, wherein the backlight device provides a backlight passing through the transmissive region;

providing a power management controller connected with the backlight device, wherein the power management controller controls an intensity of the backlight; and

forming at least one photodetector on the first substrate in the peripheral area, wherein the photodetector detects an intensity of ambient light above the first substrate, and then provides a corresponding signal to the power management controller to control the intensity of the backlight;

wherein, by the power management controller based on the corresponding signal, the intensity of the backlight automatically becomes greater when the intensity of the ambient light becomes lower, and the intensity of the backlight automatically becomes lower when the intensity of the ambient light becomes greater.

10. The method according to claim 9, further comprising the steps of:

forming a pixel electrode having a transparent portion and an opaque portion on the first substrate, wherein the transparent portion of the pixel electrode is located in the transmissive region and the opaque portion of the pixel electrode is located in the reflective region;

providing a second substrate opposite the first substrate; and

filling a space between the first substrate and the second substrate with liquid crystal molecules to form a liquid crystal layer.

11. The method according to claim 10, further comprising the steps of:

forming a thin film transistor array on the first substrate, wherein thin film transistors electrically connect the pixel electrode.

12. The method according to claim 10, wherein the transparent portion of the pixel electrode is an ITO (indium tin oxide) layer or an IZO (indium zinc oxide) layer.

13. The method according to claim 10, wherein the opaque portion of the pixel electrode is an aluminum layer or a silver layer.

14. A method of fabricating a transflective liquid crystal display device, comprising the steps of:

providing a first substrate having a viewing area and a peripheral area;

forming a metal layer on part of the first substrate in both the viewing and the peripheral areas, wherein the metal layer in the viewing area serves as a gate;

forming a gate insulating layer on the gate;

forming a semiconductor layer on the gate and the metal layer in the peripheral area;

forming a source electrode and a drain electrode on part of the semiconductor layer on the gate insulating layer;

blanketly forming an insulating layer over the first substrate;

forming a first opening and a second opening penetrating the insulating layer, wherein the first opening exposes the drain electrode and the second opening exposes the semiconductor layer in the peripheral area;

forming a transparent conductive layer in the second opening and the first opening, extending to part of the insulating layer;

forming a reflective layer on part of the insulating layer;

disposing a backlight device under the first substrate, wherein the backlight device provides a backlight passing through the transparent conductive layer extends to part of the insulating layer; and

providing a power management controller connected with the backlight device, wherein the power management controller controls an intensity of the backlight;

wherein a photodetector consists of the metal layer, the semiconductor layer and the transparent conductive layer in the peripheral area, and the photodetector detects an intensity of ambient light above the first substrate, and then provides a corresponding signal to the power management controller to control the intensity of the backlight;

wherein, by the power management controller based on the corresponding signal, the intensity of the backlight automatically becomes greater when the intensity of the ambient light becomes lower, and the intensity of the backlight automatically becomes lower when the intensity of the ambient light becomes greater.

15. The method according to claim 14, further comprising the steps of:

providing a second substrate opposite the first substrate; and

filling a space between the first substrate and the second substrate with liquid crystal molecules to form a liquid crystal layer.

16. The method according to claim 15, wherein the first substrate and the second substrate are glass substrates.

17. The method according to claim 14, wherein the metal layer is an Al layer.

18. The method according to claim 14, wherein the insulating layer is a SiO_2 layer.

19. The method according to claim 14, wherein the transparent conductive layer is an ITO (indium tin oxide) layer or an IZO (indium zinc oxide) layer.

20. The method according to claim 14, wherein the reflective layer is an aluminum layer or a silver layer.

* * * * *

专利名称(译)	透反液晶显示装置及其制造方法		
公开(公告)号	US20040227719A1	公开(公告)日	2004-11-18
申请号	US10/697122	申请日	2003-10-31
[标]申请(专利权)人(译)	章明钦 吴洋EN 陈宝轮		
申请(专利权)人(译)	常明CHIN 吴仰恩 陈伦宝		
当前申请(专利权)人(译)	常明CHIN 吴仰恩 陈伦宝		
[标]发明人	CHANG MING CHIN WU YANG EN CHEN PO LUN		
发明人	CHANG, MING-CHIN WU, YANG-EN CHEN, PO-LUN		
IPC分类号	G02F1/133 G02F1/13357 G09G3/34 G09G3/36		
CPC分类号	G02F1/1336 G02F2201/58 G02F2203/09 G09G2360/144 G09G3/3648 G09G2300/0456 G09G2320/0633 G09G3/3406		
优先权	092113026 2003-05-14 TW		
其他公开文献	US7289099		
外部链接	Espacenet USPTO		

摘要(译)

透反液晶显示装置。提供具有观察区域和周边区域的第一基板。观察区域包括透射和反射区域。背光装置设置在第一基板下方，用于提供穿过透射区域的背光。电源管理控制器连接背光装置以控制背光的强度。在外围区域中的第一基板上形成至少一个光电检测器，其中光电检测器检测第一基板上方的环境光强度，然后向电源管理控制器提供相应的信号以控制背光的强度。根据本发明，当环境光的强度变低时，背光的强度自动变大，并且当环境光的强度变大时，背光的强度自动变低。