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(54) ELECTROLUMINESCENT DISPLAY DEVICE AND MANUFACTURING METHOD OF THE SAME

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(57) **ABSTRACT**

This invention provides an organic EL display device automatically correcting light emission intensity of a display portion in accordance with intensity of external light, in which the number of components is reduced and sensitivity in detection of an external light sensor is improved. An organic EL element of top emission type, a driving TFT for driving the organic EL element, which is formed of a TFT of top gate type, and an external light sensor formed of a TFT of bottom gate type are integrally formed on a same glass substrate. Since the external light sensor is formed of a TFT of bottom gate type, external light is not blocked by a gate electrode, thereby improving sensitivity in detection of the external light.

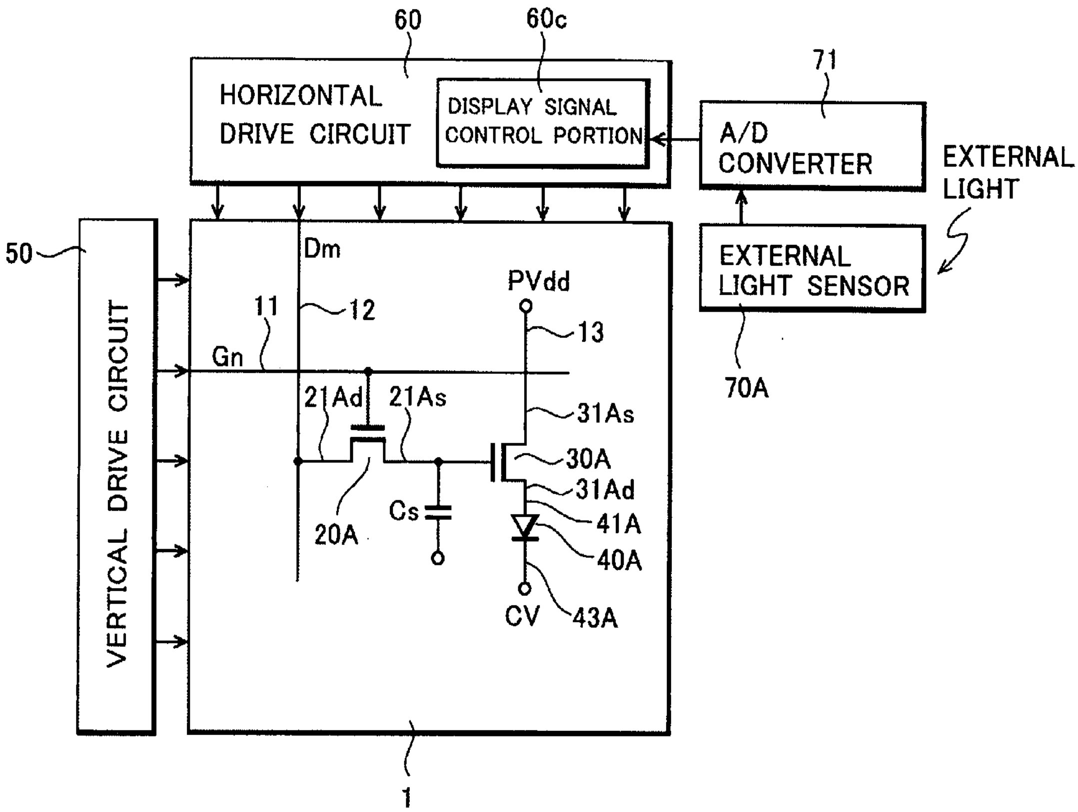


FIG. 1

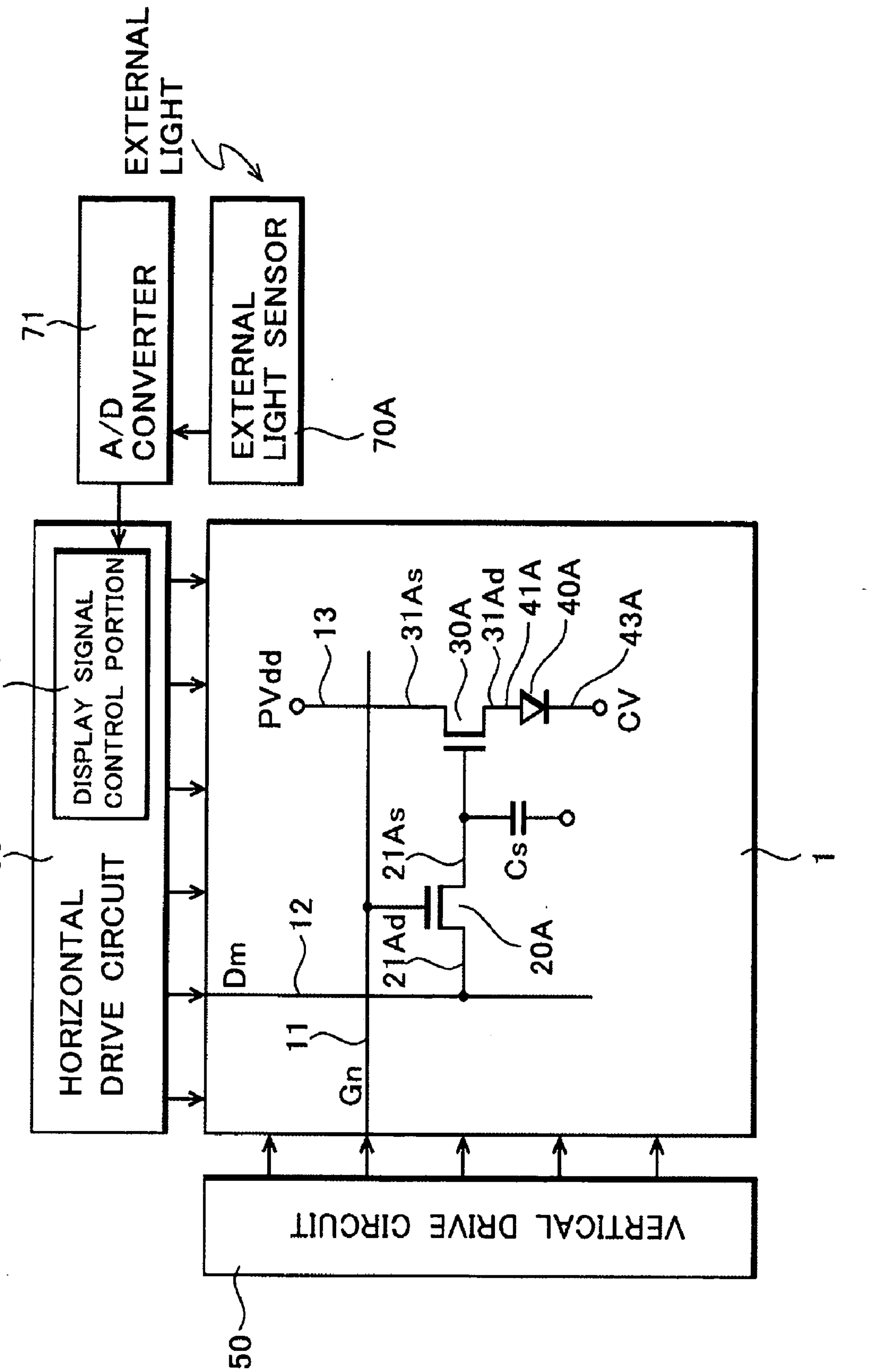

EXTERNAL LIGHT
71
A/D CONVERTER
EXTERNAL LIGHT SENSOR
70A
60c
DISPLAY SIGNAL CONTROL PORTION
60
HORIZONTAL DRIVE CIRCUIT
PVdd
13
31As
30A
31Ad
41A
40A
43A
CV
Cs
21As
21Ad
20A
12
Dm
11
Gn
1
VERTICAL DRIVE CIRCUIT
50

FIG.2

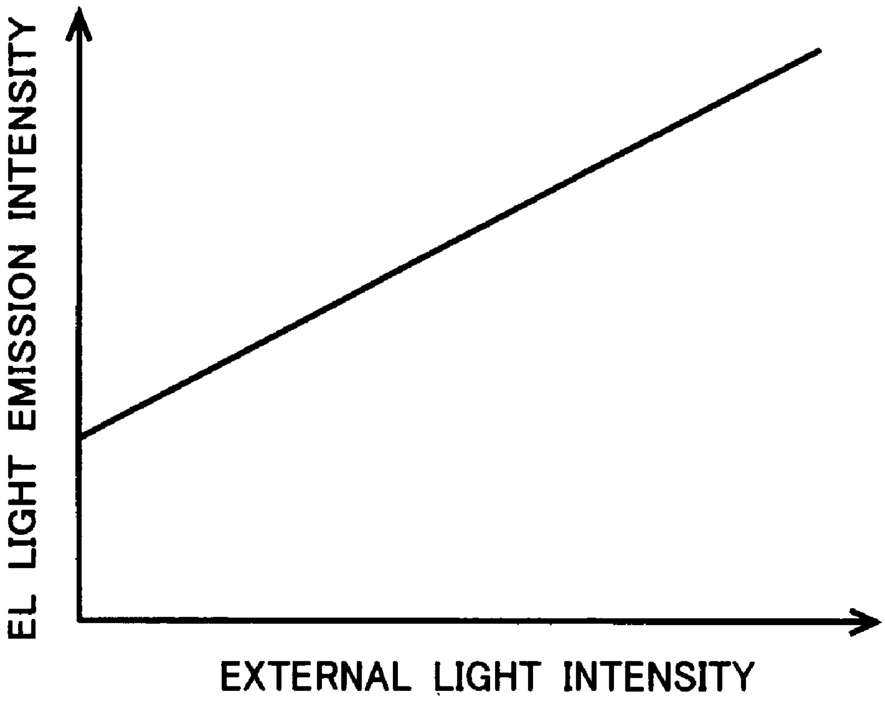


FIG.3

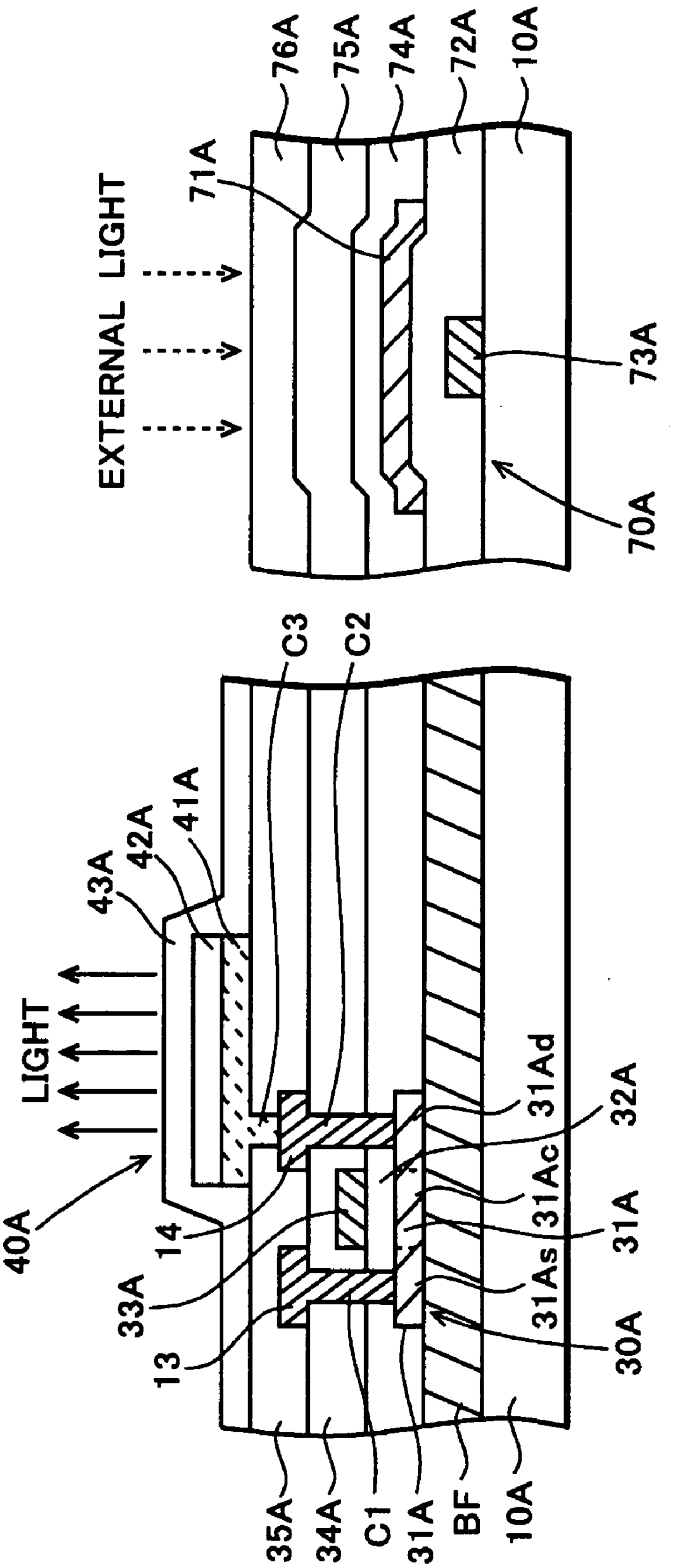

EXTERNAL LIGHT
76A
75A
74A
72A
10A
71A
73A
70A
LIGHT
40A
43A
42A
41A
C3
C2
14
33A
13
31Ad
32A
31Ac
31A
31As
30A
35A
34A
C1
31A
BF
10A

FIG.4

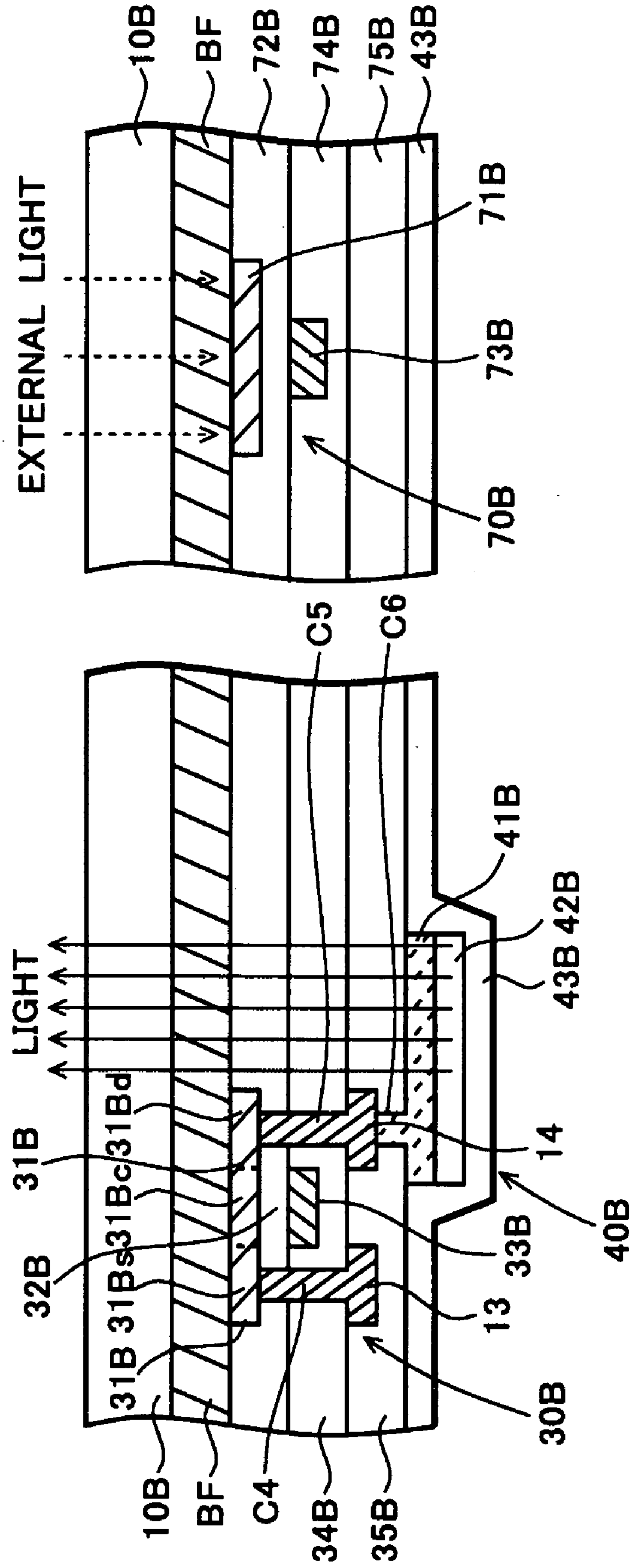

10B
BF
72B
74B
75B
43B
EXTERNAL LIGHT
71B
73B
70B
C5
C6
LIGHT
41B
43B
42B
31B
31Bd
31Bc
31Bs
32B
31B
14
33B
40B
13
30B
10B
BF
C4
34B
35B

FIG.5

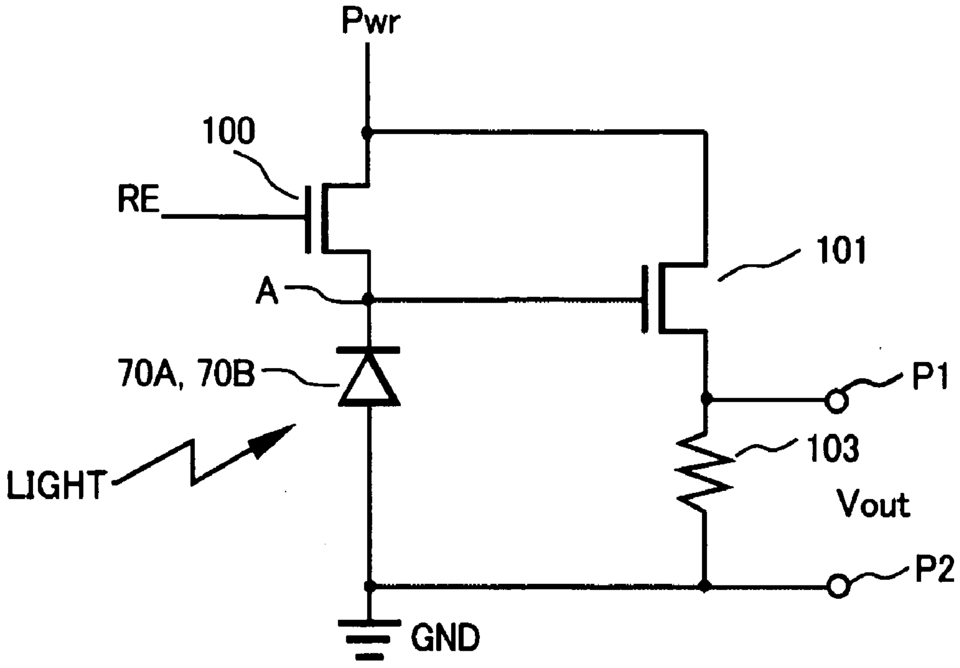
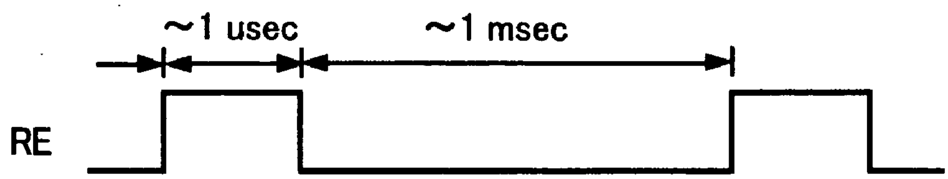


FIG.6



CIRCUIT 2

ELECTROLUMINESCENT DISPLAY DEVICE AND MANUFACTURING METHOD OF THE SAME

CROSS-REFERENCE OF THE INVENTION

[0001] This invention is based on Japanese Patent Application No. 2003-186115, the content of which is incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates to an electroluminescent display device, particularly having a function of automatically correcting light emission intensity of a display portion in accordance with external light intensity (brightness).

[0004] 2. Description of the Related Art

[0005] In recent years, an organic electroluminescent (hereafter, referred to as EL) display device using EL elements is receiving attention as a display device substituting for a CRT or an LCD. Particularly, an organic EL display device having thin film transistors (hereafter, referred to as TFTs) as switching elements for driving the organic EL elements has been developed.

[0006] The organic EL display device is applied to display panels used for cellular phones and personal digital assistants, for example. The organic EL display device, which can automatically correct light emission intensity of a display portion in accordance with intensity (brightness) of external light entering from outside of the display portion, has been also developed.

[0007] Such technologies are disclosed in the Japanese Patent Application Publication Nos. 2002-175029 and 2002-297096.

[0008] In the organic EL display device automatically correcting light emission intensity of the display portion in accordance with external light intensity, however, the display portion and an external light sensor detecting external light intensity are independently formed. This increases the number of components forming the organic EL display device, and makes a manufacturing procedure complex.

SUMMARY OF THE INVENTION

[0009] This invention provides an organic EL display device where a display portion and an external light sensor are integrally formed on the same substrate.

[0010] In the organic EL display device of the invention, an organic EL element, a driving transistor for driving the organic EL element, and an external light sensor are integrally formed on the same glass substrate. The organic EL element is formed of an organic EL element of top emission type, the driving transistor is formed of a thin film transistor of top gate type, and the external light sensor is formed of a thin film transistor of bottom gate type.

[0011] Furthermore, in an organic EL display device of the invention, the organic EL element is formed of an organic EL element of bottom emission type, the driving transistor is formed of a thin film transistor of top gate type, and the external light sensor is formed of a thin film transistor of top gate type, being integrally formed on a same glass substrate.

[0012] According to an aspect of this invention, the organic EL display device which automatically corrects the light emission intensity of the display portion in accordance with the external light intensity can be realized by integrally forming the organic EL element, the driving transistor, and the external light sensor on the same substrate. This can reduce the number of the components for the display device and simplify the manufacturing process. Furthermore, the external light sensor formed of a TFT is disposed with an active layer in a position where a gate electrode does not block the external light so that sensitivity in detection of the external light improves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a schematic circuit diagram of an organic EL display device of a first embodiment of the invention.

[0014] **FIG. 2** shows a relationship between external light intensity and EL light emission intensity in the organic EL display device of **FIG. 1**.

[0015] **FIG. 3** is a schematic cross-sectional view of an organic EL element and its periphery, and an external light sensor of the first embodiment of the invention.

[0016] **FIG. 4** is a schematic cross-sectional view of an organic EL element and its periphery, and an external light sensor of a second embodiment of the invention.

[0017] **FIG. 5** is a circuit diagram showing a structure of a sensor circuit of the first and second embodiments of the invention.

[0018] **FIG. 6** is an operational timing chart of the sensor circuit of **FIG. 5**.

DETAILED DESCRIPTION OF THE INVENTION

[0019] A structure of an organic EL display device of an embodiment of the invention will be described with reference to drawings.

[0020] **FIG. 1** is a schematic circuit diagram of an organic EL display device of a first embodiment of the invention. In this embodiment, a plurality of pixels is disposed in a matrix in a display portion **1**. **FIG. 1** shows only one pixel.

[0021] A gate signal line **11** supplying a gate signal Gn for selecting a pixel and a drain signal line **12** supplying a display signal Dm to the pixel are formed crossing each other in each of pixels. A pixel selecting TFT (thin film transistor) **20A**, an organic EL element **40A** (e.g. organic EL element of top emission type) serving as a self-emissive element, and a driving TFT (e.g. TFT of top gate type) **30A** for supplying an electric current to the organic EL element **40A** are disposed in a region enclosed with these signal lines.

[0022] A gate of the pixel selecting TFT **20A** is connected with the gate signal line **11** so as to be supplied with a gate signal Gn. A drain **21Ad** of the pixel selecting TFT **20A** is connected with the drain signal line **12** so as to be supplied with a display signal Dm. A source **21As** of the pixel selecting TFT **20A** is connected with a gate of the driving TFT **30A**. A source **31As** of the driving TFT **30A** is supplied with positive power supply voltage PVdd from a power supply line **13**. A drain **31Ad** of the driving TFT **30A** is connected with an anode **41**A of the organic EL element **40**A. A cathode **43**A of the organic EL element **40**A is supplied with power supply voltage CV.

[**0023**] The gate signal Gn is outputted from a vertical drive circuit **50** disposed on a periphery of the display portion **1**. The display signal Dm is outputted from a horizontal drive circuit **60** disposed on a periphery of the display portion **1**. The gate of the driving TFT **30**A is connected with a storage capacitor Cs. The storage capacitor Cs is provided to store the display signal Dm to be applied to the pixel for a field period by storing electric charge corresponding to the display signal Dm.

[**0024**] An external light sensor **70**A (e.g. bottom gate type) detecting external light intensity (brightness) is provided in a position where external light entering the display portion **1** can be detected. The external light sensor **70**A generates a predetermined current or voltage when receiving external light and electrically detects this, thereby detecting the external light intensity. An output terminal of the external light sensor **70**A is connected with an input terminal of an A/D converter **71**, and an output terminal of the A/D converter **71** is connected with an input terminal of the horizontal drive circuit **60**. The horizontal drive circuit **60** is provided with a display signal control portion **60***c*. The display signal control portion **60***c* has a function of changing amplitude of the display signal Dm in accordance with a digital signal (external light intensity) inputted from the A/D converter.

[**0025**] Next, an operation of the above-described organic EL display device will be described. When the gate signal Gn becomes high level for one horizontal period, the pixel selecting TFT **20**A turns on. Then, the display signal Dm is applied from the drain signal line **12** to the gate of the driving TFT **30**A through the pixel selecting TFT **20**A.

[**0026**] The conductance of the driving TFT **30**A changes in accordance with the display signal Dm supplied to the gate thereof, and a drive current in accordance with the conductance is supplied to the organic EL element **40**A through the driving TFT **30**A, thereby lighting the organic EL element **40**A. When the driving TFT **30**A turns off in accordance with the display signal Dm supplied to the gate, a drive current does not flow in the driving TFT **30**A, thereby turning off the light of the organic EL element **40**A.

[**0027**] In the above-described organic EL display device, light emission intensity of the organic EL element **40**A (hereafter, referred to as EL light emission intensity) provided in each of the pixels of the display portion **1** increases or decreases in accordance with intensity of external light entering from outside of the display portion **1**. A chart of **FIG. 2** shows a relationship between the external light intensity and the EL light emission intensity. That is, the more the external light intensity increases, the more the EL light emission intensity increases at a predetermined rate.

[**0028**] Correction of EL light emission intensity in accordance with external light intensity shown in **FIG. 2** is performed as described below. The external light sensor **70**A detects external light entering from outside of the display portion **1**, and outputs an analog signal (voltage or current) indicating external light intensity to the A/D converter **71**. The A/D converter **71** converts the analog signal entering from the external light sensor **70**A into a digital signal, and outputs the digital signal indicating the external light intensity to the display signal control portion **60***c* provided in the horizontal drive circuit **60**.

[**0029**] This display signal control portion **60***c* changes an amplitude value of the display signal Dm in accordance with each of sample values of the digital signal indicating the external light intensity, and outputs it. That is, the display signal Dm outputted by the horizontal drive circuit **60** has amplitude corresponding to the external light intensity. Therefore, when the pixel selecting TFT **20** is in an on state, the conductance of the driving TFT **30**A increases or decreases in accordance with the amplitude of the display signal Dm applied to the gate of the driving TFT **30**A. This increases or decreases a drive current to be supplied to the organic EL element **40**A, thereby completing the correction of the EL light emission intensity of the organic EL element **40**A in accordance with the external light intensity.

[**0030**] Next, structures of the organic EL element **40**A, the driving TFT **30**A, and the external light sensor **70**A will be described in detail.

[**0031**] **FIG. 3** is a schematic cross-sectional view of the organic EL element **40**A and its periphery, and the external light sensor **70**A of **FIG. 1**. The organic EL element **40**A is formed of an organic EL element of top emission type, the driving TFT **30**A for driving the organic EL element **40**A is formed of a TFT of top gate type, and the external light sensor **70**A is formed of a TFT of bottom gate type. The organic EL element **40**A, the driving TFT **30**A, and the external light sensor **70**A are formed on a same glass substrate **10**A. Hereafter, the structures of these elements will be described.

[**0032**] A buffer layer BF formed by laminating SiNx and SiO_2 in this order, an active layer **31**A formed by polycrystallizing an a-Si film by laser beam irradiation, a gate insulating film **32**A formed by laminating an SiO_2 film and an SiNx film in this order, and a gate electrode **33**A formed of a metal having a high melting point such as Cr (chromium) or Mo (molybdenum) are formed on the glass substrate **10**A in this order. The active layer **31**A is provided with a channel **31**Ac, a source **31**As, and a drain **31**Ad, the source **31**As and the drain **31**Ad being disposed on both sides of the channel **31**Ac, respectively.

[**0033**] An interlayer insulating film **34**A formed by laminating an SiO_2 film, an SiN_x film and an SiO_2 film in this order is formed on whole surfaces of the gate insulating film **32** and the gate electrode **33**A. A contact hole C**1** is provided in the interlayer insulating film **34**A in a position corresponding to the source **31**As, and a power supply line **13** supplied with positive power supply voltage PVdd is provided by filling the contact hole C**1** with metal such as Al (aluminum). A contact hole C**2** is provided in the interlayer insulting film **34**A in a position corresponding to the drain **31**Ad, and a drain electrode **14** is provided by filling the contact hole C**2** with a metal such as Al. Furthermore, a planarization insulating film **35**A for planarizing a surface, which is made of, for example, organic resin, is formed on the whole surface.

[**0034**] A contact hole C**3** is provided in the planarization insulating film **35**A in a position corresponding to the drain electrode **14**, and a metal such as Al fills the contact hole C**3**, so that the drain electrode **14** and the anode **41**A of the organic EL element **40**A are in contact with each other. The anode **41**A is an electrode having characteristics of reflecting light without transmission. This anode **41**A is made of metal such as Al, and can have a single-layered structure made of metal having a high light reflection rate or have a multi-layered structure made of ITO and a metal.

[**0035**] The organic EL element **40**A is formed in each of the pixels, being isolated as an island. The organic EL element **40**A is formed by laminating the anode **41**A, an emissive layer **42**A, and a transparent cathode **43**A transmitting light emitted by the emissive layer **42**A, in this order. The emissive layer **42**A is formed by laminating, for example, a hole transport layer, an emissive layer, and an electron transport layer (not shown). The transparent cathode **43**A is supplied with power supply voltage CV (not shown).

[**0036**] In this organic EL element **40**A, holes injected from the anode **41**A and electrons injected from the transparent cathode **43**A are recombined in the emissive layer **42**A. The recombined holes and electrons activate organic molecules forming the emissive layer **42**A to generate excitons. Then, light is emitted from the emissive layer **42**A in a process of radiation of the excitons and released outside from the transparent cathode **43**A.

[**0037**] Furthermore, on the glass substrate **10**A formed with the driving TFT **30**A and the organic EL element **40**A, the external light sensor **70**A is disposed in a position where external light from outside of the display portion **1** can be received. The external light sensor **70**A is formed of a TFT of bottom gate type.

[**0038**] That is, a gate electrode **73**A made of a metal having a high melting point such as Cr or Mo, a gate insulating film **72**A also serving as a buffer layer BF, an active layer **71**A formed by poly-crystallizing an a-Si film by laser beam irradiation, insulating films **74**A and **75**A, and a planarization insulating film **76**A are formed on the glass substrate **10**A in this order. External light enters the active layer **71**A from an exposed surface on the same side as the side of the transparent cathode **43**A serving as an emitting surface. The external light sensor **70**A electrically detects external light received by the active layer **71**A, and outputs an electric current or voltage corresponding to the intensity of the external light. In the structure of this external light sensor **70**A, the gate electrode **73**A blocking external light does not exist between the surface where external light enters and the active layer **71**A due to its bottom gate structure.

[**0039**] Therefore, an area of the active layer **71**A receiving external light increases and thus sensitivity in detection of external light improves than a case where the external light sensor **70**A is made of a TFT of top gate type (not shown) (laminated with a glass substrate, an active layer, a gate insulating film and a gate electrode in this order). The external light sensor **70**A uses the TFT of bottom gate type as a photodiode, for example, thereby outputting a photo-current corresponding to the external light.

[**0040**] As described above, in this embodiment, the organic EL element of top emission type **40**A, the driving TFT **30**A formed of a TFT of top gate type and the external light sensor **70**A formed of a TFT of bottom gate type are integrally formed on the same glass substrate **10**A. This reduces the number of elements and simplifies a manufacturing procedure. For example, a manufacturing method as described below can be employed. The gate electrode **73**A is formed on the glass substrate **10**A, and the buffer layer BF also serving as the gate insulating film **72**A is formed so as to cover the gate electrode **73**A.

[**0041**] The active layers **31**A and **71**A are formed on the buffer layer BF serving as the gate insulating film **72**A, and the gate insulating film **32**A also serving as the insulating film **74**A is formed thereon. Furthermore, the gate electrode **33**A is formed thereon, and the interlayer insulating film **34**A also serving as the insulating film **75**A is formed so as to cover the gate electrode **33**A. Then, the power supply line **13** and the drain electrode **14** are formed, and the planarization insulating films **35**A and **76**A are formed so as to cover these. The anode **41**A is formed on the planarization insulating film **35**A, and the emissive layer **42**A and the transparent cathode **43**A are formed, being laminated on the anode **41**A.

[**0042**] Since the external light sensor **70**A is formed of a TFT of bottom gate type, the external light reaches the active layer **71**A without being blocked by the gate electrode **73**A. This improves sensitivity in detecting the external light intensity.

[**0043**] Although not shown, the pixel selecting TFT **20**A is formed of a TFT of top gate type, as is the case with the driving TFT **30**A. Generally, compared to the TFT of bottom gate type, the TFT of top gate type can prevents currents from flowing in excess by activation of carriers in the active layer **31**A with EL light emission, and has a higher carrier mobility. Therefore, the TFT of top gate type is suitable for the driving TFT **30**A, and particularly for the pixel selecting TFT **20**A. On the other hand, the external light sensor **70**A utilizes a dark current flowing in the TFT, and thus does not need to have high carrier mobility.

[**0044**] Note that even the TFT of bottom gate type can also be applied to both the pixel selecting TFT **20**A and the driving TFT **30**A.

[**0045**] Next, a second embodiment of the invention will be described. In the first embodiment, the organic EL element of top emission type, the driving TFT of top gate type, and the external light sensor formed of the TFT of bottom gate type are integrally formed on the same substrate. In the second embodiment, however, an organic EL element of bottom emission type, a driving TFT of top gate TFT, and an external light sensor of a TFT of top gate type are integrally formed on the same substrate. This embodiment will be described below with reference to drawings in detail. The organic EL element **40**A of **FIG. 1** is replaced by an organic EL element of bottom emission type **40**B, and the external light sensor **70**A is replaced by an external light sensor **70**B formed of a TFT of top gate type. A schematic circuit diagram of this embodiment is the same as that of **FIG. 1**.

[**0046**] **FIG. 4** is a schematic cross-sectional view of the organic EL element **40**B and its periphery, and the external light sensor **70**B in this embodiment. As shown in **FIG. 4**, in the embodiment using the organic EL element **40**B of bottom emission type, light emitted by the organic EL element **40**B is emitted from an exposed surface of a transparent glass substrate **10**B, different from the first embodiment. Furthermore, on a surface on an opposite side of the exposed surface of the transparent glass substrate **10**B, the driving TFT **30**B of top gate type is formed.

[**0047**] That is, the buffer layer BF formed by laminating, for example, SiNx and SiO_2 in this order, an active layer **31**B formed by poly-crystallizing an a-Si film by laser beam irradiation, a gate insulating film **32**B and a gate electrode **33**B made of a metal having a high melting point such as Cr or Mo and disposed in a position corresponding to the active layer **31**B are formed on the transparent glass substrate **10**B in this order. The active layer **31**B is formed with a channel **31**Bc, a source **31**Bs, and a drain **31**Bd, the source **31**Bs and the drain **31**Bd being disposed on both sides of the channel **31**Bc, respectively.

[**0048**] An interlayer insulating film **34**B formed by laminating an SiO_2 film, an SiN_x film and an SiO_2 film in this order is formed on whole surfaces of the gate insulating film **32**B and the gate electrode **33**B. A contact hole C**4** is provided in the interlayer insulating film **34**B in a position corresponding to the source **31**Bs, and a power supply line **13** supplied with positive power supply voltage PVdd is provided therein by filling the hole with a metal such as Al. A contact hole C**5** is provided in the interlayer insulting film **34**B in a position corresponding to the drain **31**Bd, and a drain electrode **14** is provided by filling the hole with a metal such as Al.

[**0049**] Furthermore, a planarization insulating film **35**B for planarizing a surface, which is made of, for example, organic resin, is formed on the whole surface. A contact hole C**6** is provided in the planarization insulating film **35**B in a position corresponding to the drain electrode **14**, and metal such as Al fills the hole so that the drain electrode **14** and the anode **41**B of the organic EL element **40**B are in contact with each other. This transparent anode **41**B is a transparent electrode made of ITO (indium tin oxide) and so on.

[**0050**] The organic EL element **40**B is formed in each of the pixels, being isolated as an island. The organic EL element **40**B is formed by laminating the transparent anode **41**B, an emissive layer **42**B, and a cathode **43**B supplied with power supply voltage CV (not shown) (for example, made of Al, or magnesium indium alloy) in this order. Light emitted by the emissive layer **42**B is emitted from the transparent glass substrate **10**B through the transparent anode **41**B.

[**0051**] Furthermore, on the glass substrate **10**B formed with the driving TFT **30**B and the organic EL element **40**B, the external light sensor **70**B is disposed in a position where the external light from outside of the display portion **1** can be received. The external light sensor **70**B is formed of a TFT of top gate type.

[**0052**] That is, on the transparent glass substrate **10**B, the buffer layer BF formed by laminating, for example, SiNx and SiO_2, in this order, an active layer **711**B formed by poly-crystallizing an a-Si film by laser beam irradiation, a gate insulating film **72**B, a gate electrode **73**B made of a metal having a high melting point such as Cr or Mo, an interlayer insulating film **74**B, and a planarization insulating film **75**B are formed in this order. Furthermore, a cathode **43**B of the organic EL element **40**B can be formed, extending over the planarization insulating film **75**B. In this case, the external light can be blocked from entering a back surface of the external light sensor **70**B.

[**0053**] External light enters the active layer **71**B from an exposed surface on the same side as the side of the transparent glass substrate **10**B serving as an emitting surface. The external light sensor **70**B electrically detects external light received by the active layer **71**B, and outputs an electric current or voltage corresponding to the intensity of the light source.

[**0054**] In the structure of this external light sensor **70**B, a gate electrode **73**B blocking external light does not exist between the transparent glass substrate **10**B where external light enters and the active layer **71**B. This increases an area of the active layer **71**B which receives external light, and thus improves sensitivity in detecting the external light than a case where the external light sensor **70**B is formed of a TFT of bottom gate type (formed by laminating a transparent glass substrate, a gate electrode, a gate insulating film, and an active layer in this order).

[**0055**] Furthermore, although not shown, the pixel selecting TFT **20A** is formed of a TFT of top gate type, as is the case with the driving TFT **30A**.

[**0056**] In the above-described embodiment using the organic EL element **40**B of bottom emission type, the driving TFT **30**B made of a TFT of top gate type and the external light sensor **70**B are formed on the same transparent glass substrate **10**B so that the number of the elements decreases.

[**0057**] Since the external light sensor **70**B is formed of a TFT of top gate type, the external light reaches the active layer **71**B without being blocked by the gate electrode **73**B. This improves sensitivity in detecting the external light intensity.

[**0058**] Furthermore, the driving TFT **30**B and the external light sensor **70**B are formed of a TFT of top gate type, these can be formed in a same process. This can simplify a manufacturing process. For example, a manufacturing process described below can be employed.

[**0059**] The buffer layer BF is formed on the glass substrate **10**B, and the active layers **31**B and **71** are formed on the buffer layer BF. The gate insulating films **32**B and **72**B are formed on the active layers **31**B and **71**. Furthermore, the gate electrodes **33**B and **73**B are formed, and the interlayer insulating films **34**B and **74**B are formed on the insulating films **32**B and **72**B so as to cover the gate electrodes **33**B and **73**B.

[**0060**] Then, the power supply line **13** and the drain electrode **14** are formed thereon, and the planarization insulating films **35**B and **75**B are formed so as to cover the power supply line **13** and the drain electrode **14**. The transparent anode **41**B is formed on this planarization insulating film **35**B, and the emissive layer **42**B and the cathode **43**B are formed, being laminated on the transparent anode **41**B. Furthermore, the cathode **43**B of the organic EL element **40**B can be formed extending over the planarization insulating film **75**B on the external light sensor **70**B, in order to block external light from entering a back surface of the external light sensor **70**B.

[**0061**] Next, a sensor circuit using the external light sensor **70**A or **70**B will be described with reference to **FIGS. 5 and 6**. This sensor circuit is a circuit for converting light received by the external light sensor **70**A or **70**B into output voltage Vout corresponding thereto. This sensor circuit can be commonly applied to the above first and second embodiments. **FIG. 5** is a circuit diagram showing a structure of the sensor circuit, and **FIG. 6** is an operational timing chart of this sensor circuit.

[**0062**] In **FIG. 5**, the external light sensor **70**A or **70**B having a diode structure and a first resetting TFT **100** are connected in series between electric potential Pwr and ground potential GND (electric potential Pwr>ground potential GND). A second resetting TFT **101** and a resistor **103** are connected in series between the electric potential Pwr and the ground potential GND. These series circuits are connected in parallel. A gate of the first resetting TFT **100** is applied with a resetting signal RE. A gate of the second resetting TFT **101** is supplied with an electric potential of a connection point A between the external sensor **70**A or **70**B and the resetting TFT **100**.

[**0063**] Then, output voltage Vout between terminals P1 and P2, which is outputted from the terminals P1 and P2 at ends of the resistor **103**, is taken as external light detection voltage, and inputted in the above-described A/D converter **71**.

[**0064**] Note that the first and second resetting TFTs **100** and **101** are of N-channel type in this embodiment, although these TFTs **100** and **101** may be of N-channel type or of P-channel type.

[**0065**] Next, an operation of this circuit will be described with reference to **FIG. 6**. When the resetting signal RE becomes high level, the first resetting TFT **100** turns on. Accordingly, the gate of the second resetting TFT **101** is applied with electric potential Pwr through the first resetting TFT **100** so that the second resetting TFT **101** also turns on. In this resetting time, the output voltage Vout becomes approximately Pwr (predetermined value) when the impedance of the second resetting TFT **101** is smaller enough than a resistance value of the resistor **103**, and does not depend on a photocurrent flowing in the external light sensor **70**A or **70**B.

[**0066**] Next, when the resetting signal RE becomes low level for the sensing procedure, the first resetting TFT **100** turns off. The connection point A between the external light sensor **70**A or **70** and the first resetting TFT **100** becomes in a floating state. However, a leakage at the external light sensor **70**A or **70**B makes a level of the connection point A close to the ground voltage GND, and thus the potential of the gate of the second resetting TFT **101** reduces, thereby increasing impedance of the second resetting TFT **101**. As a result, the output voltage Vout becomes slightly smaller than Pwr.

[**0067**] Then, when the external light sensor **70**A or **70**B receive light, a photocurrent (a reverse bias current of a diode) corresponding to the light is generated so that electric potential of the external light sensor **70**A or **70**B (electric potential at the connection point A) reduces. This reduces the potential of the gate of the second resetting TFT **101**, thereby increasing the impedance of the second resetting TFT **101**. Accordingly, the output voltage Vout reduces.

[**0068**] Therefore, in the above-described operation, the output voltage Vout corresponding to external light intensity can be obtained, and the amplitude of the display signal Dm is controlled by using this output voltage Vout, thereby enabling correction of light emission intensity of the organic EL elements **40**A and **40**B. Note that in this sensor circuit the external light sensor **70**A and **70**B are not limited to a diode structure, but other photo sensors can be also applicable.

[**0069**] Although the organic EL elements **40**A and **40**B are used in the above described first and second embodiments, the invention is not limited to these, but non-organic EL elements can be used instead.

What is claimed is:

1. An electroluminescent display device comprising:

an electroluminescent element of top emission type disposed on a substrate; and

an external light sensor disposed on the substrate and comprising a thin film transistor of bottom gate type, the external light sensor being configured to be used for correcting light emission intensity of the electroluminescent element.

2. The electroluminescent display device of claim 1, further comprising a driving transistor of top gate type driving the electroluminescent element.

3. The electroluminescent display device of claim 1, further comprising a control portion adjusting an amplitude of a display signal supplied to the electroluminescent element in accordance with an output of the external light sensor.

4. The electroluminescent display device of claim 1, wherein the thin film transistor is configured to operate as a photodiode.

5. The electroluminescent display device of claim 3, further comprising a sensor circuit converting the output of the external light sensor into a voltage and supplying an output of the sensor circuit to the control portion.

6. The electroluminescent display device of claim 5, wherein the sensor circuit includes a first resetting transistor and the external light sensor connected in series between a first electric potential and a second electric potential and includes a second resetting transistor and a resistor connected in series between the first and second electric potentials, the first transistor is configured to receive a resetting signal at a gate thereof, and a gate of the second resetting transistor is connected to a connection point between the first resetting transistor and the external light sensor.

7. The electroluminescent display device of claim 2, wherein the driving transistor comprises a first insulating film disposed on the substrate, a first active layer formed on the first insulating film, a third insulating film disposed on the first insulating film and the first active layer, and a first gate electrode formed on the third insulating film, the external light sensor comprises a second gate electrode formed on the substrate, a second insulating film disposed on the substrate and the second gate electrode, and a second active layer formed on the second insulating film, and the first and second insulating films are each part of a same insulating layer.

8. The electroluminescent display device of claim 7, wherein the external light sensor further comprises a fourth insulating film disposed on the second insulating film and the second active layer, wherein the third and fourth insulating films are each part of another same insulating layer.

9. The electroluminescent display device of claim 7, wherein the first and second active layers are made of a same active layer material.

10. An electroluminescent display device comprising:

an electroluminescent element of bottom emission type disposed on a substrate; and

an external light sensor disposed on the substrate and comprising a thin film transistor of top gate type, the external light sensor being configured to be used for correcting light emission intensity of the electroluminescent element.

11. The electroluminescent display device of claim 10, further comprising a driving transistor of top gate type driving the electroluminescent element.

12. The electroluminescent display device of claim 10, further comprising a control portion adjusting an amplitude of a display signal supplied to the electroluminescent element in accordance with an output of the external light sensor.

13. The electroluminescent display device of claim 10, wherein the thin film transistor is configured to operate as a photodiode.

14. The electroluminescent display device of claim 12, further comprising a sensor circuit converting the output of the external light sensor into a voltage and supplying an output of the sensor circuit to the control portion.

15. The electroluminescent display device of claim 14, wherein the sensor circuit includes a first resetting transistor and the external light sensor connected in series between a first electric potential and a second electric potential and includes a second resetting transistor and a resistor connected in series between the first and second electric potentials, the first transistor is configured to receive a resetting signal at a gate thereof, and a gate of the second resetting transistor is connected to a connection point between the first resetting transistor and the external light sensor.

16. The electroluminescent display device of claim 11, wherein the driving transistor comprises a first active layer formed on the substrate, a first insulating film disposed on the substrate and the first active layer, and a first gate electrode formed on the first insulating film, the external light sensor comprises a second active layer formed on the substrate, a second insulating film disposed on the substrate and the second active layer, and a second gate electrode formed on the second insulating film, and the first and second insulating films are each part of a same insulating film.

17. The electroluminescent display device of claim 16, wherein the first and second active layers are made of a same active layer material.

18. The electroluminescent display device of claim 16, wherein the first and second gate electrodes are made of a same gate electrode material.

19. The electroluminescent display device of claim 10, wherein the electroluminescent element comprises two electrodes and an organic material layer disposed between the two electrodes, and one of the two electrodes that is disposed further from the substrate than another of the two electrodes covers the external light sensor.

20. A method of manufacturing an electroluminescent display device having an electroluminescent element disposed on a substrate, a driving transistor disposed on the substrate and driving the electroluminescent element, and an external light sensor disposed on the substrate and comprising a transistor, the method comprising:

forming a gate electrode of the external light sensor on the substrate;

depositing a first insulating film on the substrate and the gate electrode of the external light sensor;

depositing a layer of an active layer material on the first insulating film;

patterning the deposited layer to form an active layer of the driving transistor and an active layer of the external light sensor;

depositing a second insulating film on the first insulating film, the active layer of the driving transistor and the active layer of the external light sensor; and

forming a gate electrode of the driving transistor on the second insulating film.

21. A method of manufacturing an electroluminescent display device having an electroluminescent element disposed on a substrate, a driving transistor disposed on the substrate and driving the electroluminescent element, and an external light sensor disposed on the substrate and comprising a transistor, the method comprising:

depositing a layer of an active layer material on the substrate;

patterning the deposited layer to form an active layer of the driving transistor and an active layer of the external light sensor;

depositing a first insulating film on the active layer of the driving transistor and the active layer of the external light sensor; and

forming, on the first insulating film, a gate electrode of the driving transistor and a gate electrode of the external light sensor.

22. The method of manufacturing the electroluminescent display device of claim 21, further comprising depositing a second insulating film on the substrate prior to the depositing of the layer of the active layer material.

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摘要(译)

本发明提供一种有机EL显示装置，其根据外部光的强度自动校正显示部分的发光强度，其中减少了部件的数量并提高了外部光传感器的检测灵敏度。顶部发射型有机EL元件，用于驱动有机EL元件的驱动TFT，由顶栅型TFT形成，以及由底栅型TFT形成的外部光传感器一体地形成在同一玻璃上基质。由于外部光传感器由底栅型TFT形成，外部光不被栅电极阻挡，从而提高了外部光检测的灵敏度。