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Yamazaki et al.

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(54) **LIGHT-EMITTING DEVICE**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**[7] **H01J 1/62**

(52) **U.S. Cl.** **313/498**; 313/500; 313/505; 315/169.1; 345/46; 257/99; 257/11

(58) **Field of Search** 313/498, 500, 313/505, 169.1, 169.3, 501–504, 506–512; 345/44–46, 55; 257/99–103; 315/169.1, 169.2, 169.3

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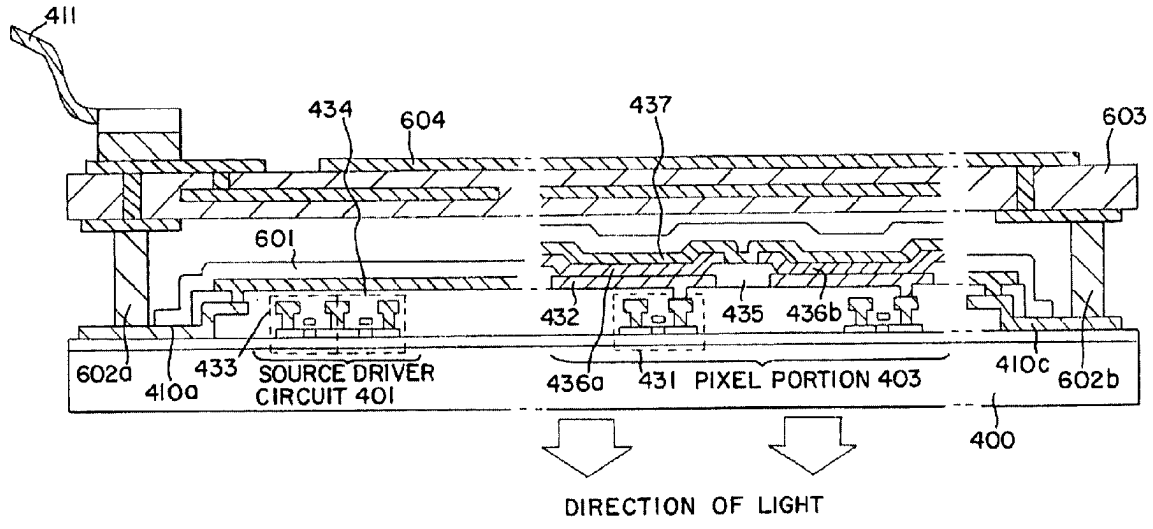
(57) **ABSTRACT**

A light-emitting device having the quality of an image high in homogeneity is provided. A printed wiring board (second substrate) **(107)** is provided facing a substrate (first substrate) **(101)** that has a luminous element **(102)** formed thereon. A PWB side wiring (second group of wirings) **(110)** on the printed wiring board **(107)** is electrically connected to element side wirings (first group of wirings) **(103, 104)** by anisotropic conductive films **(105*a*, 105*b*)**. At this point, because a low resistant copper foil is used to form the PWB side wiring **(110)**, a voltage drop of the element side wirings **(103, 104)** and a delay of a signal can be reduced. Accordingly, the homogeneity of the quality of an image is improved, and the operating speed of a driver circuit portion is enhanced.

18 Claims, 8 Drawing Sheets



BOE 1009

FIG. 1A

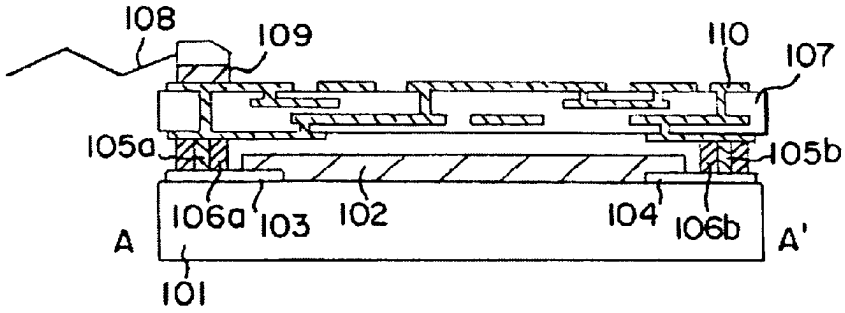


FIG. 1B

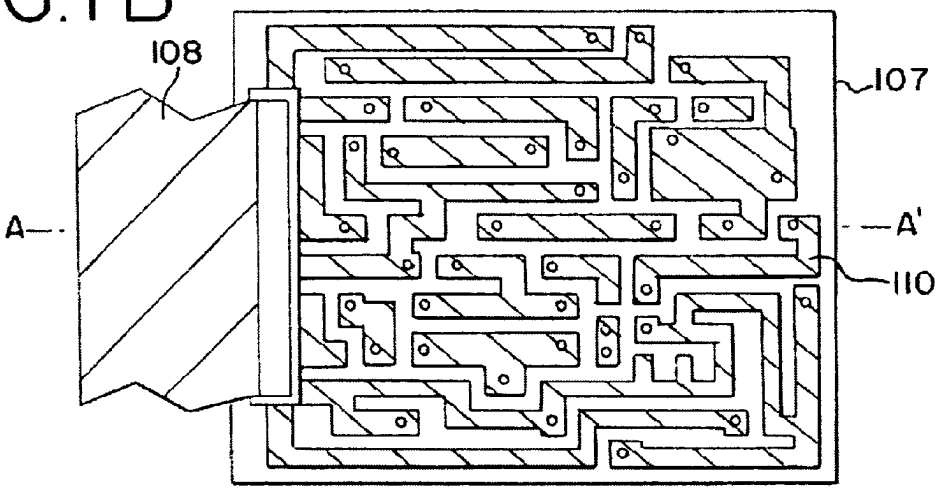


FIG. 2

PRIOR ART

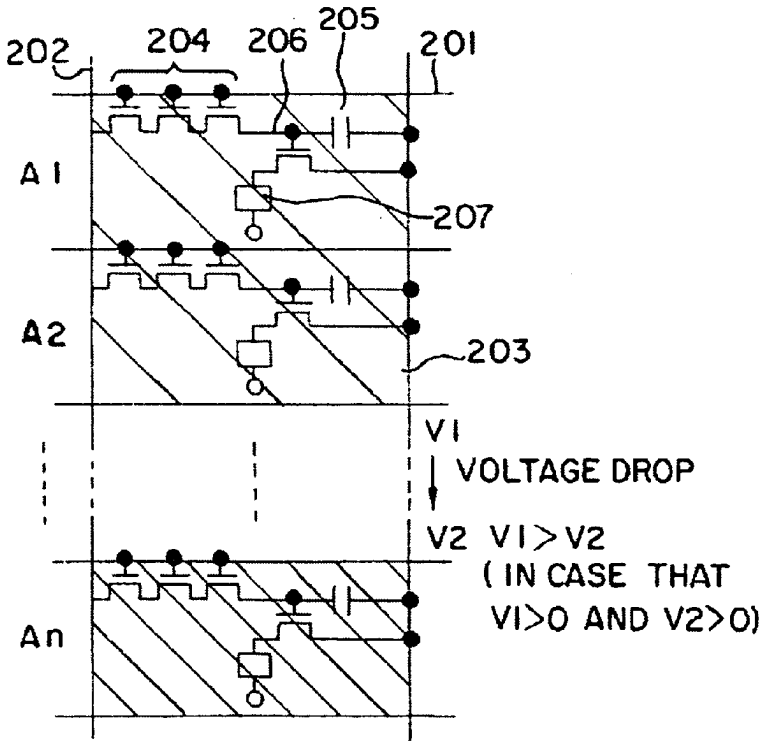


FIG. 3A

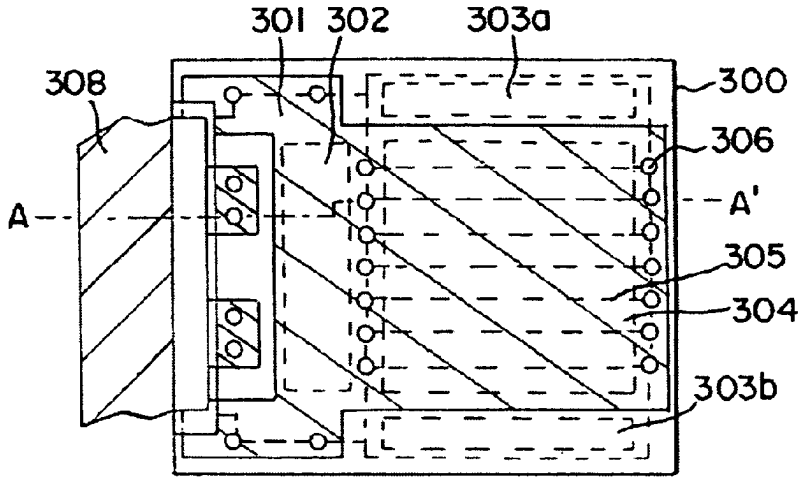


FIG. 3B

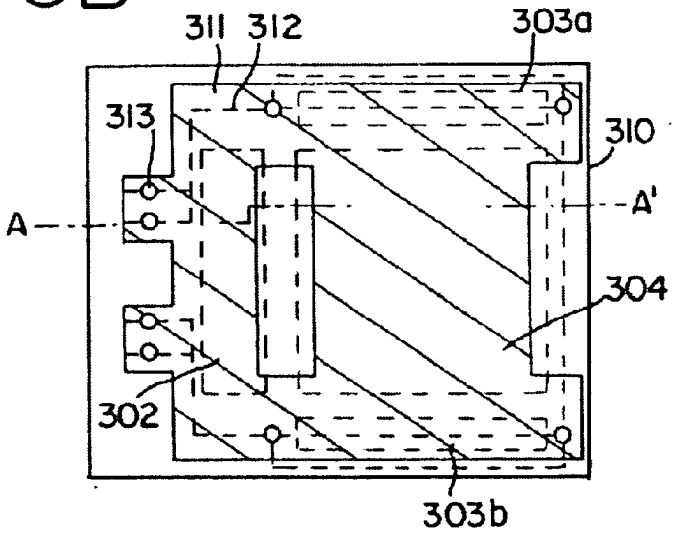
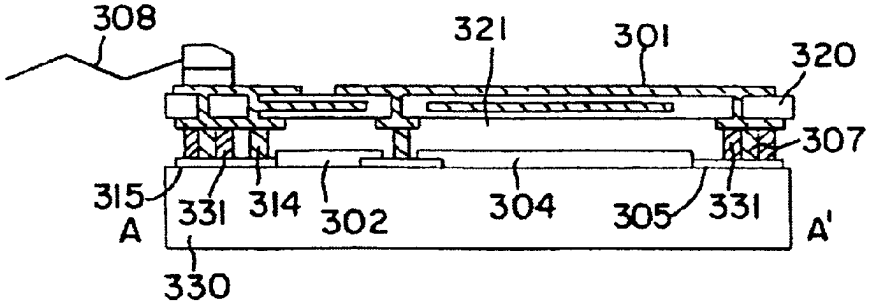


FIG. 3C



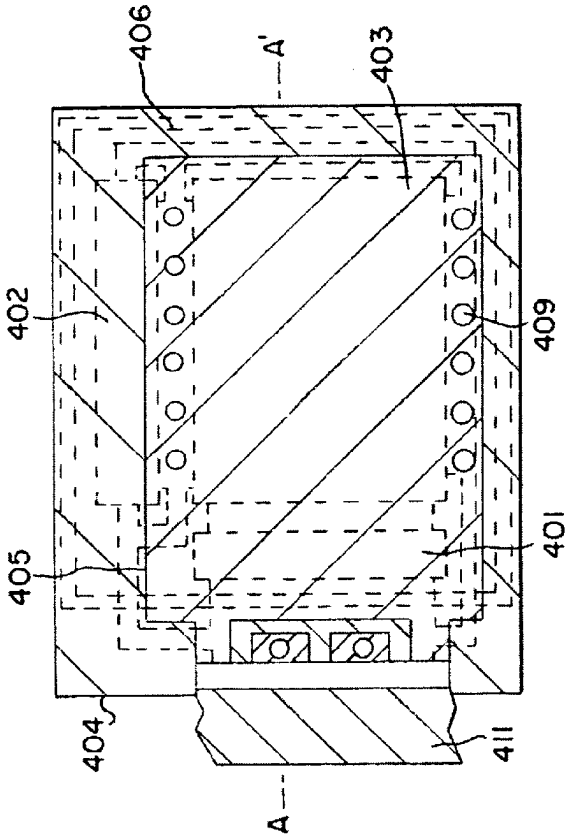

406
A'
403
402
409
405
401
404
411
A

FIG. 4A

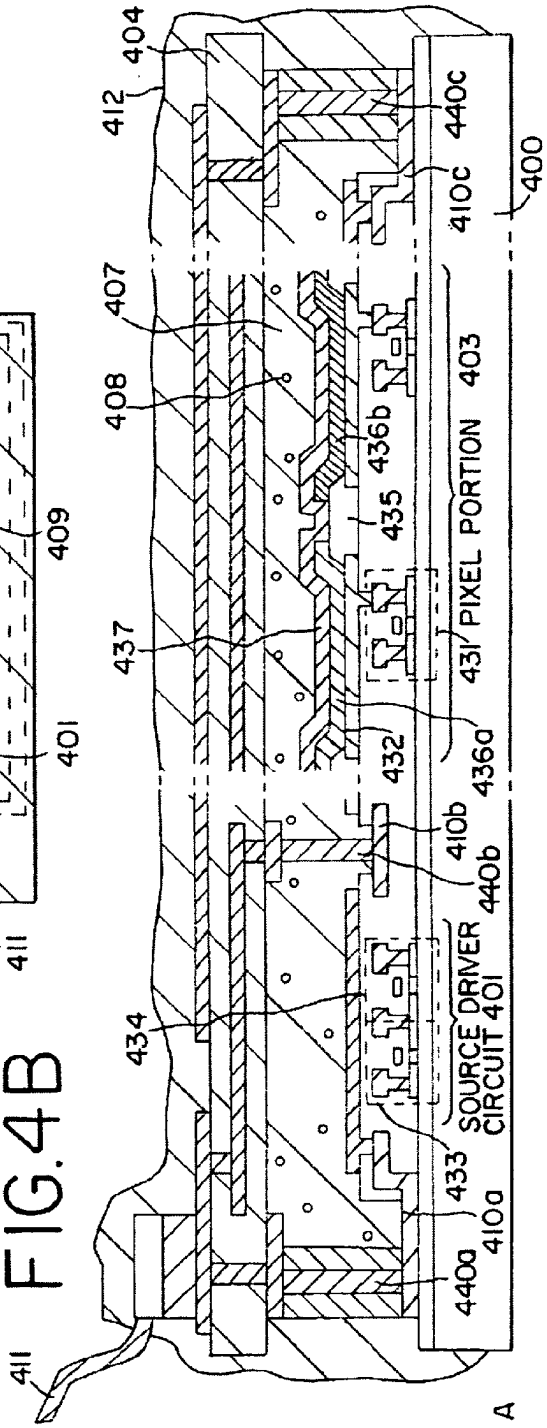

404
412
440c
400
410c
407
408
436b
435
403
PIXEL PORTION
431
437
432
436a
410b
440b
SOURCE DRIVER CIRCUIT 401
434
433
410a
440a
411
A

FIG. 4B

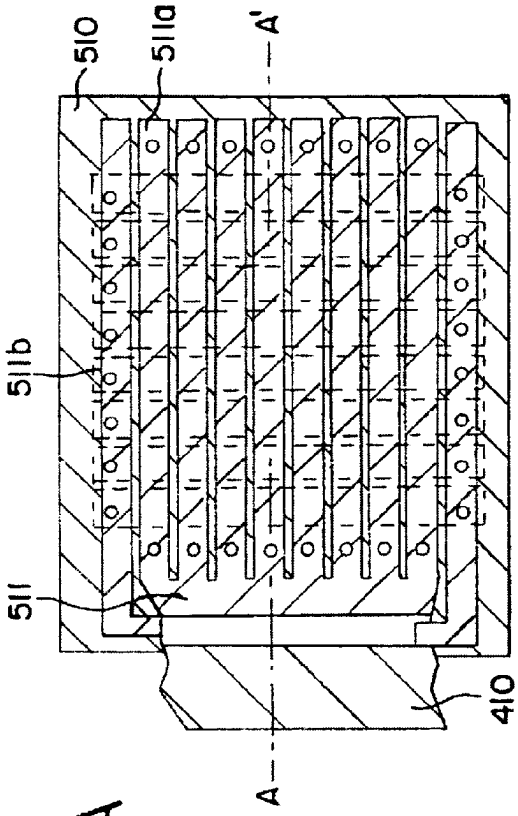

510
511a
A'
511b
511
410
A

FIG. 5A

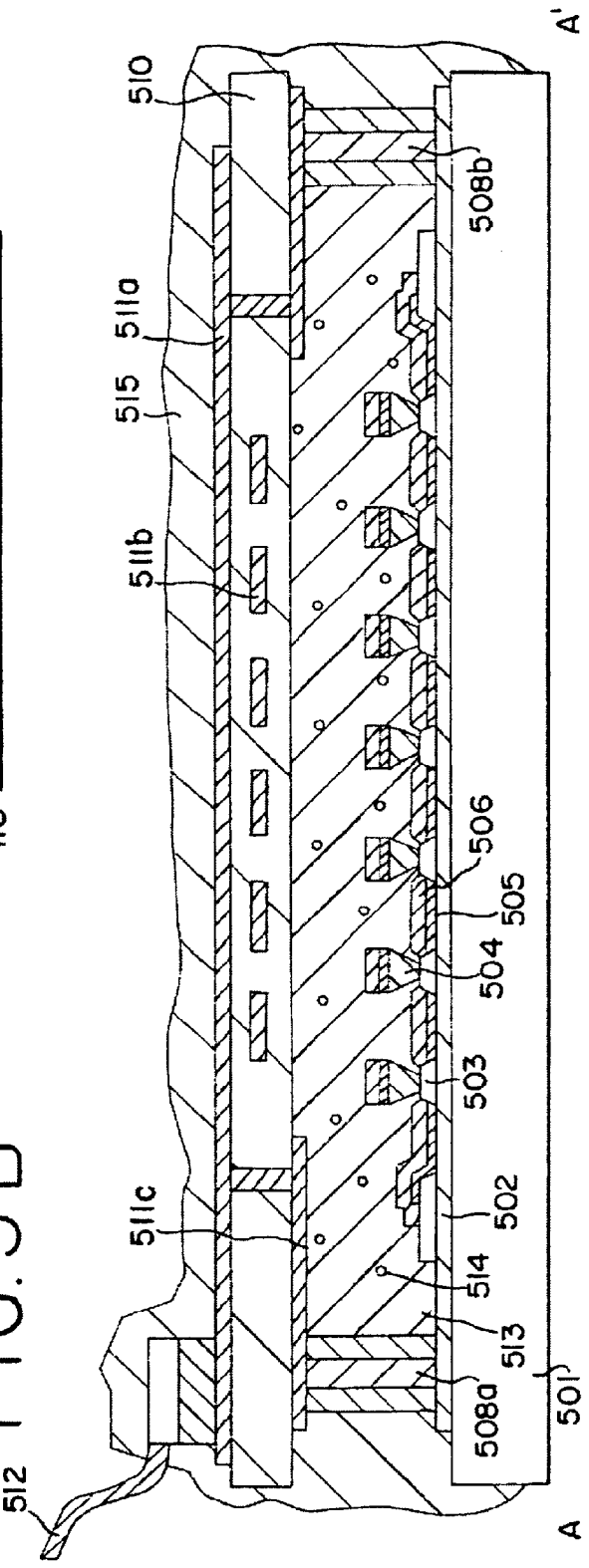

A'
510
508b
511a
515
511b
506
505
504
503
502
511c
514
513
508a
501
512
A

FIG. 5B

FIG. 6

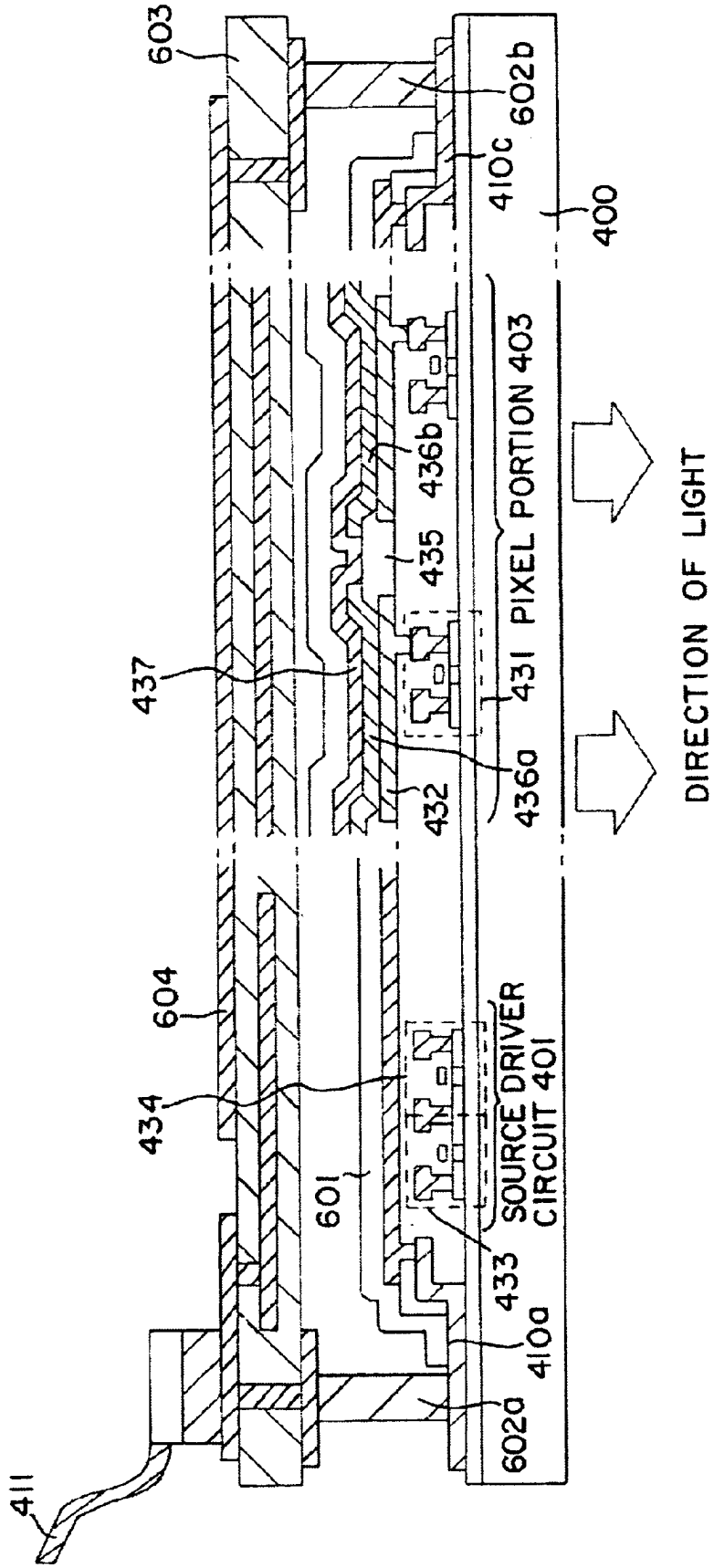

603
602b
410c
400
436b
435
431 PIXEL PORTION 403
437
436a
432
DIRECTION OF LIGHT
604
434
601
433
SOURCE DRIVER CIRCUIT 401
410a
602a
411

FIG. 7

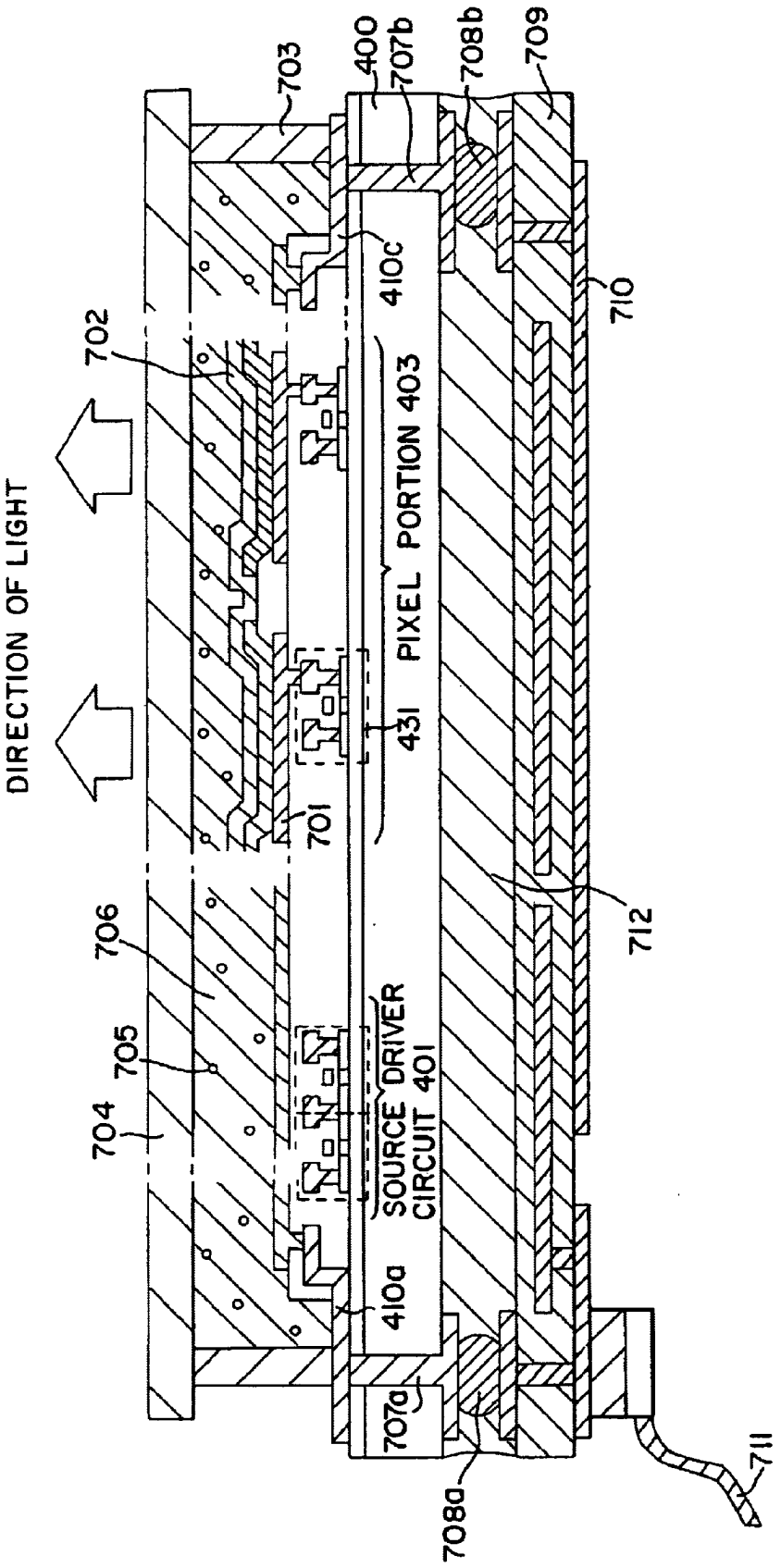

DIRECTION OF LIGHT
702
703
400
707b
708b
709
410c
710
PIXEL PORTION 403
431
701
706
705
704
SOURCE DRIVER CIRCUIT 401
712
410a
707a
708a
711

FIG.8A

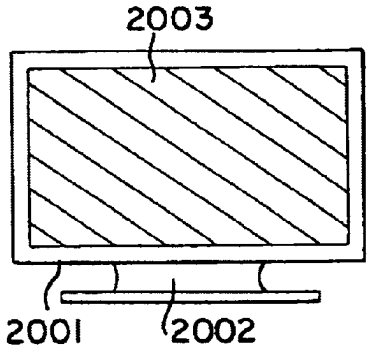


FIG.8B

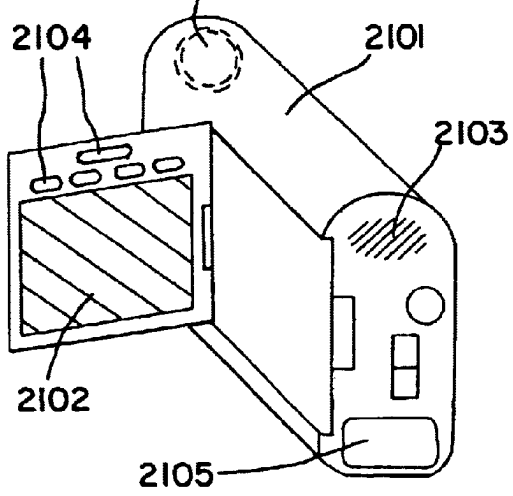


FIG.8C

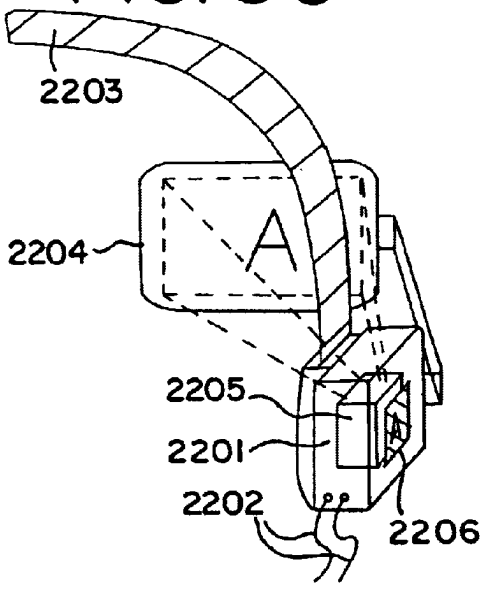


FIG.8D

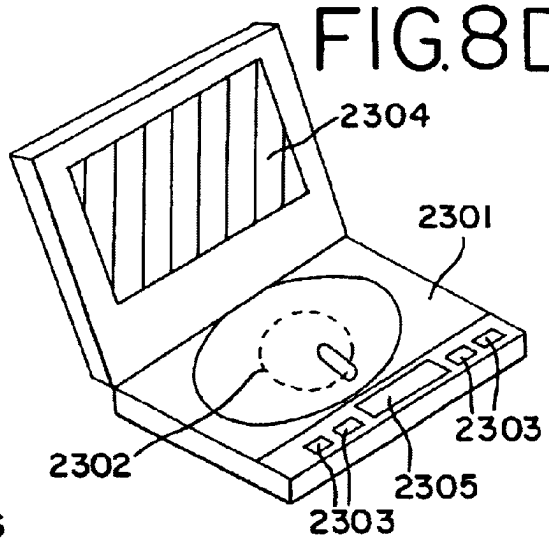


FIG.8E

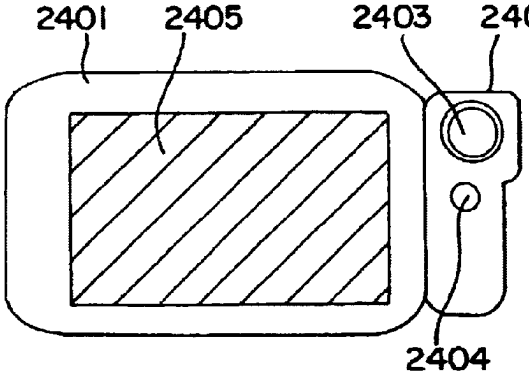


FIG.8F

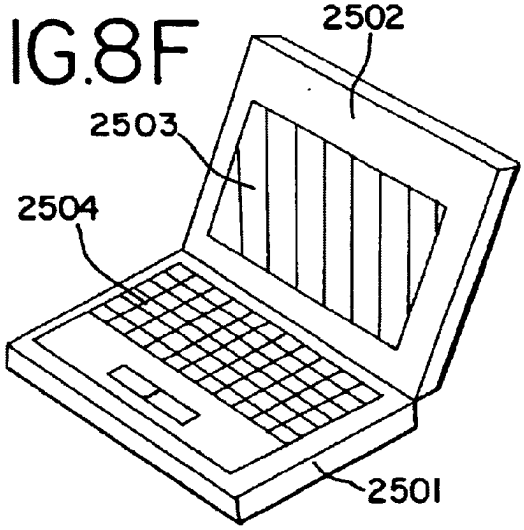


FIG. 9A

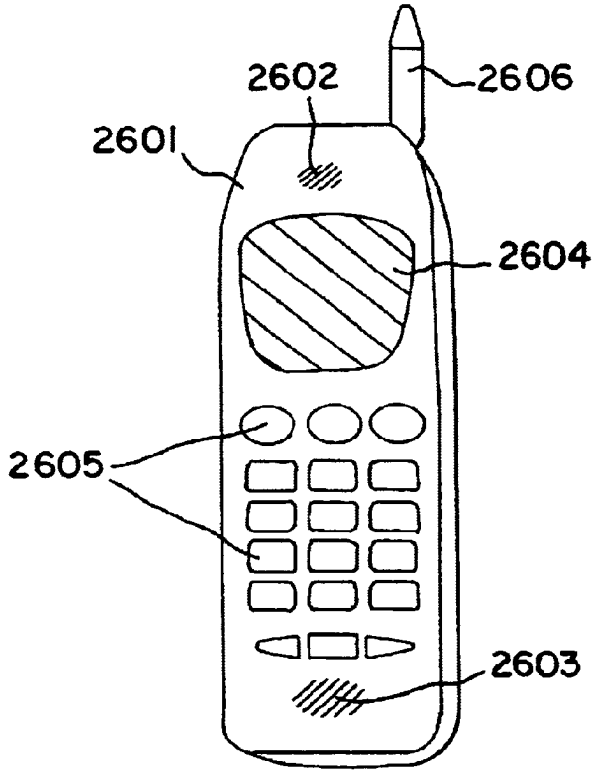
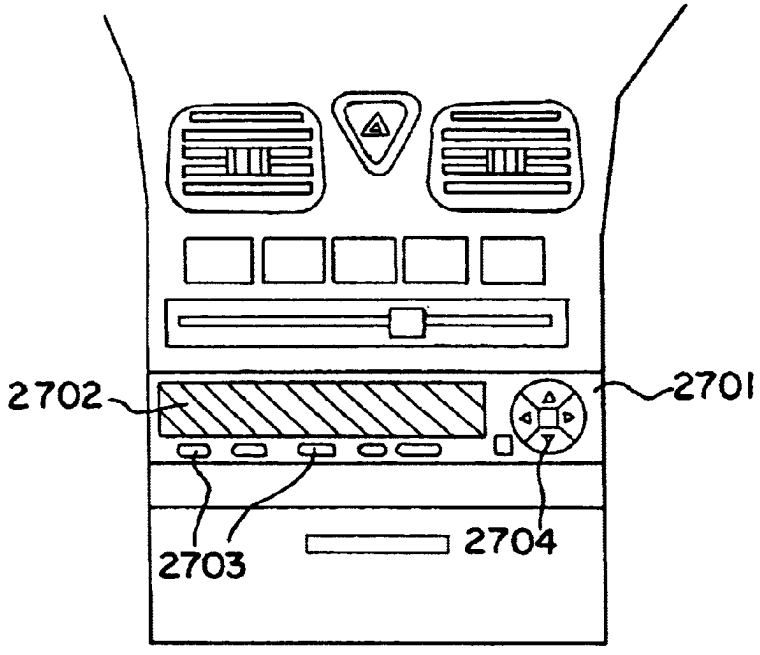


FIG. 9B



LIGHT-EMITTING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a device having an element (hereinafter referred to as luminous element) that is comprised of a luminous material sandwiched between electrodes (the device will hereinafter be referred to as light-emitting device), and to a method of manufacturing the same. Specifically, the present invention relates to a light-emitting device using a luminous material that provides EL (Electro Luminescence) (hereinafter referred to as EL material).

2. Description of the Related Art

In recent years, development is proceeding in a light-emitting device (EL display device) using a luminous element that utilizes the EL phenomenon of a luminous material (hereinafter referred to as EL element). The EL display device is a display device that uses a luminous element which itself has a light-emitting ability, that is, self-emissive, and hence, unlike a liquid crystal display device, does not need a back light. In addition, the EL display device has merits such as a wide field of vision, light weight, and a low power consumption.

Such an El display device is constructed of a structure that has an EL element composed of an anode, a cathode, and an EL material sandwiched therebetween. By applying a voltage between the anode and the cathode to make a current flow in the EL material, carriers re-couple, whereby the EL element emits light. Such a driving method is called a current drive. However, in the EL display device which has the current drive, there is a problem of a phenomenon in which a voltage drop (also referred to as an IR drop) caused by a wiring resistance occurs. This phenomenon is that the voltage becomes lower as its distance from a power source becomes farther even if it is the voltage of the same wiring. This problem is particularly conspicuous when the wiring becomes long. Thus, it is a large obstacle in making the screen of the EL display device larger.

When the wiring is made of a material such as tantalum, tungsten, or silicon, the EL display device is susceptible to the influence of the wiring resistance, which may become the cause of immensely reducing the homogeneity of the quality of the image. In addition, in case of using a low resistant material such as aluminum or copper, when the draw-around distance is long, then the same thing can be observed, i.e., the aforementioned phenomenon will occur.

The above-mentioned problem will be explained here with reference to FIG. **2**. Shown in FIG. **2** is a portion of a pixel portion of an active matrix EL display device. An □n number of pixels denoted by A_1, A_2, . . . A_n are arranged □n the up and down direction (vertical direction) of the diagram. Reference symbol **201** denotes a gate wiring, **202** denotes a source wiring, and **203** denotes a current supply line. Furthermore, a switching TFT **204**, a storage capacitor **205**, a current control TFT **206**, and an EL element **207** are formed in a region that is surrounded by the gate wiring **201**, the source wiring **202** , and the current supply line **203**.

At this point, the voltage of the current supply line **203** drops as the current supply line **203** moves towards the bottom of the diagram due to the influence of the voltage drop. That is, a voltage V_1 that was in the upper part of the pixel portion becomes a voltage V_2 in the lower part of the pixel portion, becoming a relationship of $V_1 > V_2$. This

influence becomes more conspicuous as the area of the pixel portion (image display region) is made larger.

As a result, in case of making the EL elements of each of the pixels emit light in the same brightness, the pixel denoted by A_1 and the pixel denoted by A_2 will emit light in about the same brightness. However, the brightness of the light emitted by the pixel denoted by A_n declines compared with the pixel denoted by A_1 and the pixel denoted by A_2. The reason for this originates in that the voltage applied to the EL element of the pixel denoted by A_n has declined due to the voltage drop.

Further, the influence of such voltage drop is imparted not only to the current supply line **203** but also to the gate wiring **201** and the source wiring **202**. In other words, there is a concern that the gate wiring **201** may not be able to open a gate of the switching TFT **204** because of the voltage drop. In addition, the source wiring **202** becomes incapable of applying a desired voltage to a gate of the current control TFT **206** due to the voltage drop, leading to a fear that the brightness of the EL element will change or that the EL element will not emit light.

Thus, the transmission of a desired voltage becomes impossible because of the voltage drop which originates in the wiring resistance. Consequently, a drawback in which there is a considerable loss in the homogeneity of the quality of the image in the pixel portion occurs. Attempts such as contriving to apply a voltage to both ends of the wiring have been made in order to improve the above problem. However, because the wiring is drawn around longer, as a result, the influence of the voltage drop cannot be ignored.

In case of manufacturing a monolithic type light-emitting device in which a driver circuit portion (typically including a gate driver circuit and a source driver circuit) is integrated on the same substrate, the wiring resistance of a wiring that is drawn around between the driver circuit portion and an input terminal of an electric signal becomes a problem. The wiring resistance induces a delay of the electric signal, and therefore there is a concern that the operating speed of the gate driver circuit and the source driver circuit will be reduced.

Thus, drawbacks such as the considerable loss of the homogeneity of the quality of the image and the extreme decline in the operating speed of the driver circuit portion due to the voltage drop which originates in the wiring resistance and the delay of a signal occur. Such a problem becomes a particularly conspicuous problem in a light-emitting device having a large screen that is several tens inches in diagonal.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above, and therefore has an object to provide a light-emitting device that has a homogenized quality of image by suppressing an influence of a voltage drop which originates in the above-mentioned wiring resistance. Further, another object of the present invention is to suppress a delay of a wiring which electrically connects a driver circuit portion and an input/output terminal to thereby enhance the operating speed of the driver circuit portion.

The light-emitting device of the present invention is constituted of a substrate having a luminous element formed thereon (hereinafter referred to as element-formed substrate or a first substrate) and a hardened large printed wiring board (PWB: Printed Wiring Board), which are electrically connected by a conductor (anisotropic conductive film or a bump), and is characterized in that the resistance of each of

the wirings (first group of wirings) formed on the element-formed substrate is reduced.

It is to be noted that the hardened large printed wiring board (hereinafter referred to as printed wiring board or a second substrate) indicates a printed wiring board that has a level of hardness which does not bend or curve to some amount of impact. Typically, the hardened large printed wiring board prefers to a printed wiring board that is formed of a material selected from a glass cloth epoxy, glass cloth heat-resistant epoxy, ceramic, alumina, paper-based phenol, or paper-based epoxy. In addition, it is also possible to use a transmissive glass substrate, a quartz substrate, or a plastic substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and features of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings:

FIGS. **1**A and **1**B are diagrams showing a cross-sectional structure and a top structure of a light-emitting device, respectively;

FIG. **2** is a diagram illustrating the change in brightness of a pixel;

FIGS. **3**A and **3**B are diagrams showing top structures of a light-emitting device, and FIG. **3**C is a diagram showing a cross-sectional structure thereof;

FIGS. **4**A and **4**B are diagrams showing a top structure and a cross-sectional structure of an EL display device, respectively;

FIGS. **5**A and **5**B are diagrams showing a top structure and a cross-sectional structure of an EL display device, respectively;

FIG. **6** is a diagram showing a cross-sectional structure of an EL display device;

FIG. **7** is a diagram showing a cross-sectional structure of an EL display device;

FIGS. **8**A to **8**F are views showing electric equipments of the present invention; and

FIGS. **9**A and **9**B are views showing electric equipments of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The cross-sectional view of the light-emitting device of the present invention is shown in FIG. **1**A, and the top view thereof is shown in FIG. **1**B. Note that the cross-sectional view taken along the line A_A' of FIG. **1**B corresponds to FIG. **1**A.

In FIG. **1**A, reference symbol **101** denotes a substrate having a luminous element **102** (typically an EL element or a semiconductor diode element) formed thereon. Wirings **103** and **104** for transmitting an electric signal (hereinafter referred to as element side wiring) to the luminous element **102** are formed on the substrate **101**. These components correspond to the above-mentioned element-formed substrate. It is to be noted that a glass substrate, a quartz substrate, a plastic substrate, a silicon substrate, a ceramic substrate, or a metallic substrate may be used as the substrate **101**.

A printed wiring board **107** is electrically connected to the substrate **101** via conductors **105***a* and **105***b* that are provided on the wirings **103** and **104** of the element-formed substrate. It is to be noted that reference symbols **106***a* and **106***b* denote sealing agents for bonding the element-formed substrate **101** and the printed wiring board **107** together.

Furthermore, a group of wirings (second group of wirings) are formed on the front surface, the back surface or the interior of the printed wiring board **107**. When the wirings are formed in two or more different layers, it is referred to as a multi-layered wiring (or a lamination wiring) in the present specification. On the other hand, when one layer of wiring is formed in either the front surface, the back surface, or the interior, then it is referred to as a single-layered wiring in the present specification. In the present invention, the printed wiring board **107** may have either the multi-layered wiring or the single-layered wiring.

At this point, an anisotropic conductive film, a conductive paste or a bump can be used as the conductors **105***a* and **105***b*. As the bump, typically, a solder bump, a metal bump, a nickel bump, or a copper bump can be used. In addition, resin having metallic particles such as silver and nickel dispersed therein can be used as the conductive paste.

An FPC (Flexible Printed Circuit) **108** is attached to a terminal portion of the printed wiring board **107**. Further, a wiring **110** for transmitting an electric signal, which was transmitted to an anisotropic conductive film **109**, to the conductors **105***a* and **105***b* is formed to a thickness of between 1 and 20 μm (hereinafter referred to as PWB side wiring or the second group of wirings). Typically, a pattern formed of a copper foil, a gold foil, a silver foil, a nickel foil, or an aluminum foil is used as the PWB side wiring **110**. Note that though the FPC is a printed wiring board in a broad sense, it is not included in the definition of the printed wiring board in the present invention.

In the light-emitting device of the present invention incorporating the above-mentioned structure, an electric signal transmitted to the FPC **108** is transmitted to the conductors **105***a* and **105***b* by the PWB side wiring **110**, and then the signal can be transmitted to the luminous element **102** via the element side wirings **103** and **104**. At this point, because the PWB side wiring **110** is made of an extremely low resistant wiring, the voltage drop which originates in the wiring resistance can be immensely suppressed, thereby making it possible to transmit nearly equivalent electric signals to the element side wirings **103** and **104**. Similarly, the wiring resistance of the PWB side wiring **110** is small, and therefore, the delay of a signal is largely suppressed. Consequently, it is possible to improve the drawback of the reduction in the operating speed of the driver circuit.

Further, a characteristic of the present invention is that a material selected from a glass cloth epoxy, glass cloth heat-resistant epoxy, ceramic, alumina, paper-based phenol, or paper-based epoxy is used as the material of the printed wiring board **107** so that the printed wiring board **107** has an impact-resistant property. As a result, it becomes possible to protect the luminous element from external impact, whereby a highly reliable light-emitting device can be attained.

A case of manufacturing an EL display device by employing the present invention will be explained in Embodiment Mode of the present invention. The top views of the EL display device manufactured by employing the present invention is shown in FIGS. **3**A and **3**B.

Note that in Embodiment Mode, the top views of the EL display device are shown in FIGS. **3**A and **3**B, and the cross-sectional view thereof is shown in FIG. **3**C. FIG. **3**C is a cross-sectional view taken along the line A–A[] in the top views of FIGS. **3**A and **3**B. Further, a printed wiring board is formed from a two-layered structure in Embodiment Mode, and the respective layers are shown in FIGS. **3**A and **3**B.

In FIG. **3**A, reference symbol **300** denotes a first printed wiring board, and a wiring **301** for aiding a current supply

line (hereinafter referred to as current supply auxiliary line) is formed thereon. In the present specification, the current supply line is a wiring for supplying a current, which flows to an EL element, to each EL element, and the wiring for aiding the current supply line is a wiring that is connected in parallel to the current supply line in order to reduce the apparent wiring resistance of the current supply line. The wiring for aiding the current supply line can be made of a metallic film of copper, silver, gold, aluminum or nickel, or an alloy film containing as a main component a material selected from copper, silver, gold, aluminum, or nickel. Also, the wiring for aiding the current supply line can be formed into a layered structure made of a metallic film that is made of two or more different elements selected from copper, silver, gold, aluminum and nickel.

Further, a dotted line denoted by reference symbol **302** is a source driver circuit, dotted lines denoted by reference symbols **303***a* and **303***b* are gate driver circuits, and a dotted line denoted by reference symbol **304** is a pixel portion. These driver circuits and the pixel portion are formed on an element-formed substrate **330** (refer to FIG. **3**C). In addition, a thick dotted line denoted by reference symbol **305** is a current supply line that is formed on the element-formed substrate **330**. In a contact portion **306** at this point, the current supply auxiliary line **301** is electrically connected to a conductor **307**, and further electrically connected to the current supply line **305** via the conductor **307**.

Thus, the current supply auxiliary line **301** that is made of a low resistant material such as a copper foil is formed on the first printed wiring board **300**. The current supply auxiliary line **301** is electrically connected to the current supply line **305**, that is formed on the element-formed substrate **330**, via the contact portion **306**. Accordingly, it is possible to make the electric potential equal in any position of the current supply line **305**, and therefore, the voltage drop of the current supply line **305** can be substantially suppressed.

In FIG. **3**B, reference symbol **310** denotes a second printed wiring board, and a wiring **311** for aiding a gate control wiring (hereinafter referred to as gate control auxiliary line) is formed thereon. In the present specification, the gate control wiring is a wiring for transmitting a power source signal of the gate driver circuit, a clock signal, or a start signal, and the wiring for aiding the gate control wiring is a wiring that is connected in parallel to the gate control wiring in order to reduce the apparent wiring resistance of the gate control wiring.

Further, the thick dotted line denoted by reference symbol **312** is a gate control wiring that is formed on the element-formed substrate. At this point, the gate control auxiliary line **311** is electrically connected to a conductor **314** via a contact portion **313**, and then further electrically connected to a gate control wiring **315** via the conductor **314**.

Thus, the gate control auxiliary line **311** that is made of a low resistant material such as a copper foil is formed on the second printed wiring board **310**. The gate control auxiliary line **311** is electrically connected to the gate control wiring **312** that is formed on the element-formed substrate **330** via the contact portion **313**. Accordingly, it is possible to make the electric potential equal in any position of the gate control wiring **312**, and therefore, the voltage drop of the gate control wiring **312** can be substantially suppressed.

In Embodiment Mode of the present invention, the first printed wiring board **300** and the second printed wiring board **310** are first adhered to each other (denoted as printed wiring board **320**), and then the adhered boards are bonded with the element-formed substrate **330** by using a sealing agent **331**. Either the first printed wiring board **300** or the second printed wiring board **310** is electrically connected to the element-formed substrate **330** through the conductor **307** or **314**. It is to be noted that there is no limit to the position of providing the conductors **307** and **314**.

In Embodiment Mode, the gap between the printed wiring board **320** and the element-formed substrate **330** is prescribed by the height of the anisotropic conductive film, conductive paste or bump. It is desirable that the gap is formed between 5 μm and 1 mm (preferably between 10 and 100 μm). If the gap is too narrow, then the printed wiring board **320** and the luminous element may be in contact with each other. On the other hand, if the gap is too wide, then it becomes difficult for the anisotropic conductive film, conductive paste, or bump to secure the gap. Note that a spacer or a filler used in a liquid crystal may be used to secure the gap.

Furthermore, an inert gas (preferably argon gas, neon gas, nitrogen gas, or helium gas) or resin may be filled in an airtight space **321** between the element-formed substrate **330** and the printed wiring board **320**. As the resin, ultraviolet cured resin, thermosetting resin, silicone resin, epoxy resin, acrylic resin, polyimide resin, phenol resin, PVC (polyvinyl chloride), PVB (polyvinyl butylal), or EVA (ethylenevinyl acetate) may be used.

It is effective to provide a moisture absorbent material (typically barium oxide or cesium oxide) together with the inert gas or the resin in the interior of the airtight space **321**.

An important point in Embodiment Mode of the present invention is that a low resistant wiring pattern provided in the printed wiring board is electrically connected to the current supply line **305** and the gate control wiring **312** which readily become the wiring resistant problem. Thus, the occurrence of the voltage drop caused by the wiring resistance of the current supply line **305** and the gate control wiring **312** can be suppressed, whereby an EL display device that may perform a homogeneous image display can be manufactured.

Embodiment 1

In Embodiment **1**, an explanation will be made with reference to FIGS. **4**A and **4**B on an active matrix EL display device that is manufactured by employing the present invention. FIG. **4**A is a top view of an element-formed substrate (denoted by reference symbol **400** in FIG. **4**B) having an EL element formed thereon. Indicated by the dotted lines, reference symbol **401** denotes a source driver circuit, **402** denotes a gate driver circuit, and **403** denotes a pixel portion.

Further, reference symbol **404** denotes a printed wiring board, and a PWB side wiring **405** is formed thereon. The dotted line indicated by reference symbol **406** denotes a first sealing member, and in the inner side surrounded by the first sealing member **406**, resin (denoted by reference symbol **407** in FIG. **4**B) is provided between the printed wiring board **404** and the element-formed substrate **400**. It is to be noted that barium oxide (denoted by reference symbol **408** in FIG. **4**B) is used as the moisture absorbent material doped into the resin **407**.

Reference symbol **409** denotes a contact portion which electrically connects the PWB side wiring **405** and connecting wirings **410***a* to **410***c* that are formed on the element-formed substrate **400**. An electric signal such as a video signal or a clock signal inputted from an FPC (Flexible Printed Circuit) **411**, which serves as a connecting terminal with an external device, is transmitted to the PWB side wiring **405**, and then is transmitted to the current supply line via the contact portion **409**.

A cross-sectional view corresponding to the cross-section taken along the line A_A[] of FIG. **4**A is shown in FIG. **4**B.

It is to be noted that in FIGS. **4**A and **4**B, the same reference symbols are used to denote the same components. As shown in FIG. **4**B, the pixel portion **403** and the source side driver circuit **401** are formed on the substrate **400**. The pixel portion **403** is formed of a plurality of pixels each including a TFT **431** for controlling the current that flows to an EL element (hereinafter referred to as current control TFT) and a pixel electrode **432** electrically connected to the drain of the current control TFT **431**. Further, the source side driver circuit **401** is formed using a CMOS circuit in which an N channel TFT **433** and a P channel TFT **434** are combined complementarily.

The pixel electrode **432** is formed of a transparent conducting film (a film made of a compound of indium oxide and tin oxide in Embodiment 1) and functions as an anode of the EL element. An insulating film **435** is formed on both ends of the pixel electrode **432** where a light-emitting layer **436***a* luminescing red, a light-emitting layer **436***b* luminescing green, and a light-emitting layer luminescing blue (not shown in the drawing) are further formed. A light shielding conductive film (an alloy film of lithium and aluminum in Embodiment 1) is used to form a cathode **437** of the EL element that is further formed thereon.

Regarding the film deposition method of the light-emitting layers **436***a* and **436***b*, any known method may be used, and an organic material or an inorganic material can be used as the material for forming the light-emitting layers. The structure of the light-emitting layer do not have to only be the light-emitting layer, but may be a lamination structure in which an electron injection layer, an electron transportation layer, a hole transportation layer, and a hole injection layer are combined.

In case of Embodiment 1, the cathode **437** also functions as a common wiring shared by all the pixels, and is electrically connected to the connecting wirings **410***a* to **410***c*. The connecting wirings **410***a* to **410***c* are electrically connected to the PWB side wiring **405** by anisotropic conductive films **440***a* to **440***c*. Furthermore, because the PWB side wiring **405** is electrically connected to the FPC **411**, as a result, the connecting wirings **410***a* to **410***c* become electrically connected to the FPC **411**.

Note that in Embodiment 1, the first sealing member **406** is formed by using a dispenser or the like, and a spacer (not shown) is sprayed to bond the first sealing member **406** to the printed wiring board **404**. The resin **407** is then filled into a space surrounded by the element-formed substrate **400**, the printed wiring board **404**, and the first sealing member **406**. Although resin doped with barium oxide as the moisture absorbent material is used in Embodiment 1, the barium oxide can be sealed inside the resin in massive distributions. In addition, as the material of the not shown spacer, a moisture absorbent material may be used.

Next, after curing the resin **407** by ultraviolet irradiation or heat application, an opening portion (not shown) formed in the first sealing member **406** is closed. Then, a second sealing member **412** is disposed so as to cover a portion of the first sealing member **406**, the printed wiring board **404**, and the FPC **411**. The second sealing member **412** may be formed of the same material as the first sealing member **406**.

By sealing the EL element within the resin **407** using the method as described above, the EL element is completely cut off from external environment, and the invasion by substances such as moisture and oxygen from the outside which accelerate the oxidation degradation of the organic material thus can be prevented. Accordingly, an EL display device with high reliability can be manufactured.

Further, the occurrence of the voltage drop caused by the wiring resistance of the current supply line and the gate control wiring provided on the element-formed substrate can be suppressed by employing the present invention, whereby an EL display device that may perform a homogeneous image display can be manufactured.

Embodiment 2

In Embodiment 2, an explanation will be made with reference to FIGS. **5**A and **5**B on a passive matrix EL display device that is manufactured by employing the present invention. It is to be noted that FIG. **5**A is a top view thereof and FIG. **5**B is a cross-sectional view thereof taken along the line A_A of FIG. **5**A.

In FIG. **5**B, reference symbol **501** denotes an element-formed substrate made of plastic, and reference symbol **502** denotes an anode made of a compound of indium oxide and zinc oxide. In Embodiment 2, the anode **502** is formed by the evaporation method. Though not shown in FIGS. **5**A and **5**B, it is to be noted that a plurality of anodes are arranged in stripe shapes in a parallel direction in a defined space.

An insulating film **503** is formed such that it is orthogonal to the plurality of anodes **502** arranged in stripe shapes. In addition, the insulating film **503** is also provided in the gaps of the anodes **502** in order to insulate each of the anodes **502** separately. Therefore, the insulating film **503** is patterned into matrix when observed from the top.

Further, a bank **504** made of resin is formed on the insulating film **503**. The bank **504** is formed in a perpendicular direction in the space such that it is orthogonal to the anodes **502**. The shape of the bank **504** is processed into an inverted triangle (inverted taper shape). Note that the structure may be a two-layered structure where the upper layer having an eaves-shape is on the lower layer.

Thereafter, a light-emitting layer **505** and a cathode **506** made of an aluminum alloy are formed in succession. It is preferable to successively form both the light-emitting layer **505** and the cathode **506** under a vacuum or inert atmosphere because the light-emitting layer **505** is easily affected by moisture and oxygen. The light-emitting layer **505** may be formed of any known material. However, a polymer-based organic material is preferred from the view point of an easy and simple film deposition. Also, it is preferable that the cathode **506** is formed by the evaporation method. The light-emitting layer **505** and the cathode **506** are both formed in the grooves which are formed by the bank **504**. Both are arranged in stripe shapes in a perpendicular direction in the defined space.

Though not shown in the figures, it is effective to provide a hole transportation layer or a hole injection layer as a buffer layer between the light-emitting layer **505** and the cathode **506**. Material such as copper pthalocyanine, polythiophene, or PEDOT can be used as the hole injection layer.

Thus, an EL element is formed on the element-formed substrate **501** by the above described method. Note that because the bottom electrode serves as a transmissive anode in Embodiment 2, the light generated in the light-emitting layer **505** is irradiated in a direction towards the bottom surface (in the direction towards the element-formed substrate **501**) in the defined space.

The anodes **502** are electrically connected to a PWB side wiring **511** that is formed on a printed wiring board **510** by anisotropic conductive films **508***a* and **508***b* which are provided inside a first sealing member **507**. In Embodiment 2, the PWB side wiring **511** is a three-layered structure made up of a wiring **511***a* provided on the front surface of the printed wiring board **510**, a wiring **511***b* provided in the interior thereof, and a wiring **511***c* provided on the back surface thereof. The materials cited in the explanation of FIG. **1** can be used as the material to form the printed wiring board **510**.

At this point, as shown in FIG. **5**A, the wiring **511***a* provided on the front surface of the printed wiring board **510** and the wiring **511***b* provided in the interior thereof are formed such that they are orthogonal to each other. The wiring **511***a* provided on the front surface of the printed wiring board **510** is electrically connected to the anodes **502**, and the wiring **511***c* provided on the back surface thereof is electrically connected to the cathode **506**. Further, the wiring **511***a* provided on the front surface of the printed wiring board **510** is electrically connected to an FPC **512** to thereby transmit a signal from an external equipment.

In Embodiment 2, the space between the element-formed substrate **501** and the printed wiring board **510** is provided with a resin **513** and a moisture absorbent material **514** that is doped into the resin **513** to thereby protect the EL element from moisture and oxygen. Of course, the space may be filled with inert gas instead of filling the space with the resin. In addition, a second sealing member **515** is provided so as to cover the entire printed wiring board **510** to thereby suppress the deterioration of the EL element.

By sealing the EL element within the resin **513** using the method as described above, the EL element is completely cut off from external environment, and the invasion by substances such as moisture and oxygen from the outside which accelerate the oxidation degradation of the organic material thus can be prevented. Accordingly, an EL display device with high reliability can be manufactured.

Further, the occurrence of the voltage drop caused by the wiring resistance of the anodes and cathodes provided on the element-formed substrate can be suppressed by employing the present invention, whereby an EL display device that may perform a homogeneous image display can be manufactured.

Embodiment 3

Shown in Embodiment 3 is a modified example of the structure of the EL display device described in Embodiment 1. The description thereof will be made with reference to FIG. **6**. Structures of a TFT and an EL element formed on the element-formed substrate **400** are the same as those of FIGS. **4**A and **4**B. Therefore, only different components will be denoted with reference symbols and explained.

Upon forming a structure similar to that of Embodiment 1 up to the formation of the cathode **437**, a passivation film **601** is further formed to a thickness of 50 to 500 nm (preferably between 300 and 400 nm) to cover the cathode **437**. As the passivation film **601**, a tantalum oxide film, a silicon nitride film, a silicon oxide film, a silicon oxide nitride film, or a lamination film of a combination thereof may be used. It is preferable that the film deposition thereof is performed at a temperature of 150° C. or less by vapor-phase deposition such that the EL element will not deteriorate.

The sealing of the EL element is completed by the passivation film **601** in Embodiment 3. That is, the EL element is protected from external substances such as moisture and oxygen by the passivation film **601**, and hence Embodiment 3 is characterized in that the reliability of the EL display device is enhanced. Accordingly, though the structure shown in FIGS. **4**A and **4**B is one in which the EL element is sealed by the resin **407** for protection from external substances, in Embodiment 3, there is no need to particularly perform such sealing. As a result, the structure of the EL display device can be simplified.

At this point, anisotropic conductive films **602***a* and **602***b* are not only electrically connected to the connecting wirings **410***a* to **410***c* and a PWB side wiring **604** that is formed on a printed wiring board **603**, but also carry the role of a spacer for determining the gap between the element-formed substrate **400** and the printed wiring board **603**. Of course, a separate spacer may be provided.

By sealing the EL element with the passivation film **601** using the method as described above, the EL element is completely cut off from external environment, and the invasion by substances such as moisture and oxygen from the outside which accelerate the oxidation degradation of the organic material thus can be prevented. Accordingly, an EL display device with high reliability can be manufactured.

Further, the occurrence of the voltage drop caused by the wiring resistance of the current supply line and the gate control wiring provided on the element-formed substrate can be suppressed by employing the present invention, whereby an EL display device that may perform a homogeneous image display can be manufactured.

Note that the constitution of Embodiment 3 may be combined with the constitution of Embodiment 1.

Embodiment 4

Shown in Embodiment 4 is a modified example of the structure of the EL display device described in Embodiment 1. The description thereof will be made with reference to FIG. **7**. Structures of a TFT and an EL element formed on the element-formed substrate **400** are basically the same as those of FIGS. **4**A and **4**B. Therefore, only different components will be denoted with reference symbols and explained.

In Embodiment 4, the structure of the EL element is a reversed one from that of FIGS. **4**A and **4**B. A light shielding conductive film (an aluminum alloy film in Embodiment 4) is used as a pixel electrode (cathode) **701**, and a transparent conductive film (a compound film of indium oxide and zinc oxide in Embodiment 4) is used as an anode **702**. Thus, the direction of the light emitted is a direction towards the upper part of the diagram (direction indicated by an arrow).

Upon completion of the EL element, a covering member **704** is bonded by a first sealing member **703**, and the inside thereof is provided with a resin **706** that is doped with a moisture absorbent material **705**. A transmissive material can be used as the covering member **704**, and a resin film, a resin substrate, a plastic substrate, a glass substrate, or a quartz substrate may be used.

Next, a via hole is formed from the back surface of the element-formed substrate **400** to thereby form connecting wirings **707***a* and **707***b*. The connecting wirings **707***a* and **707***b* are further electrically connected to a PWB side wiring **710** that is formed on a printed wiring board **709** via bumps **708***a* and **708***b* which are made of gold, solder, or nickel. The PWB side wiring **710** is electrically connected to an FPC **711**. It is to be noted that reference symbol **712** denotes a resin for bonding the element-formed substrate **400** and the printed wiring board **709**. However, it may be a structure without the provision of the resin **712**.

The occurrence of the voltage drop caused by the wiring resistance of the current supply line and the gate control wiring provided on the element-formed substrate can be suppressed by employing the structure of Embodiment 4, whereby an EL display device that may perform a homogeneous image display can be manufactured.

Embodiment 5

Examples of the light-emitting device employing the EL element were explained in Embodiments 1 through 4. However, the present invention may also be employed in an EC (Electro Chromic) display device, a field emission display (FED) or a light-emitting device having a light-emitting diode that employs a semiconductor.

Embodiment 6

The light-emitting device formed by implementing the present invention has superior visibility in bright locations in comparison to a liquid crystal display device because it is a self-emissive type device, and moreover its angle of vision is wide. Accordingly, it can be used as a display portion for various electronic equipment. For example, for appreciation of TV broadcasts by large screen, it is appropriate to use a display of the present invention incorporating the light-emitting device in its casing and having a diagonal equal to 20 to 60 inches.

Note that all displays for exhibiting information such as a personal computer display, a TV broadcast reception display, or an advertisement display are included as the display incorporating a light-emitting device in its casing. Further, the light emitting device of the present invention can be used as a display portion of the other various electronic equipment.

The following can be given as examples of such electronic equipment: a video camera; a digital camera; a goggle type display (head mounted display); a car navigation system; an audio reproducing device (such as a car audio system, an audio component system); a notebook personal computer; a game equipment; a portable information terminal (such as a mobile computer, a mobile telephone, a mobile game equipment or an electronic book); and an image playback device provided with a recording medium (specifically, a device which performs playback of a recording medium and is provided with a display which can display those images, such as a digital video disk (DVD)). In particular, because portable information terminals are often viewed from a diagonal direction, the wideness of the angle of vision is regarded as very important. Thus, it is preferable that the EL display device is employed. Examples of these electronic equipment are shown in FIGS. **8** and **9**.

FIG. **8**A is a display incorporating a light-emitting device in its casing, containing a casing **2001**, a support stand **2002**, and a display portion **2003**. The present invention can be used in the display portion **2003**. Since the display is a self-emissive type device without the need of a backlight, its display portion can be made thinner than a liquid crystal display device.

FIG. **8**B is a video camera, containing a main body **2101**, a display portion **2102**, a voice input portion **2103**, operation switches **2104**, a battery **2105**, and an image receiving portion **2106**. The light emitting device of the present invention can be used in the display portion **2102**.

FIG. **8**C is a portion of a head fitting type EL display (right side), containing a main body **2201**, a signal cable **2202**, a head fixing band **2203**, a display portion **2204**, an optical system **2205**, and a light emitting device **2206**. The present invention can be used in the light emitting device **2206**.

FIG. **8**D is an image playback device (specifically, a DVD playback device) provided with a recording medium, containing a main body **2301**, a recording medium (such as a DVD) **2302**, operation switches **2303**, a display portion (a) **2304**, and a display portion (b) **2305**. The display portion (a) is mainly used for displaying image information, and the image portion (b) is mainly used for displaying character information, and the light emitting device of the present invention can be used in these image portions (a) and (b). Note that domestic game equipment is included as the image playback device provided with a recording medium.

FIG. **8**E is a mobile computer, containing a main body **2401**, a camera portion **2402**, an image receiving portion **2403**, operation switches **2404**, and a display portion **2405**. The light emitting device of the present invention can be used in the display portion **2405**.

FIG. **8**F is a personal computer, containing a main body **2501**, a casing **2502**, a display portion **2503**, and a keyboard **2504**. The light emitting device of the present invention can be used in the display portion **2503**.

Note that in the future if the emission luminance becomes higher, the projection of light including outputted images can be enlarged by lenses, optical fiber, or the like. Then it will become possible to use the light emitting device in a front type or a rear type projector.

The emitting portion of the light emitting device consumes power, and therefore it is preferable to display information so as to have the emitting portion become as small as possible. Therefore, when using the light emitting device in a display portion which mainly displays character information, such as a portable information terminal, in particular, a portable telephone and an audio reproducing device, it is preferable to drive it by setting non-emitting portions as background and forming character information in emitting portions.

FIG. **9**A is a portable telephone, containing a main body **2601**, a voice output portion **2602**, a voice input portion **2603**, a display portion **2604**, operation switches **2605**, and an antenna **2606**. The light emitting device of the present invention can be used in the display portion **2604**. Note that by displaying white characters in a black background in the display portion **2604**, the power consumption of the portable telephone can be reduced.

FIG. **9**B is an audio reproducing device, specifically a car audio system, containing a main body **2701**, a display portion **2702**, and operation switches **2703** and **2704**. The light emitting device of the present invention can be used in the display portion **2702**. Furthermore, an audio reproducing device for a car is shown in Embodiment 6, but it may also be used for a mobile type and a domestic type of audio reproducing device. Note that by displaying white characters in a black background in the display portion **2704**, the power consumption can be reduced. This is particularly effective in a mobile type audio reproducing device.

The range of applications of the present invention is thus extremely wide, and it is possible to apply the present invention to electronic equipment in all fields. Furthermore, any constitution of the light emitting device shown in Embodiments 1 to 6 may be employed in the electronic equipment of this embodiment.

Embodiment 7

In the case that an electric equipment having a light-emitting device according to the present invention as a display portion is used outdoors, of course the display portion is viewed sometimes when it is dark and sometimes when it is light. Though, when it is dark, what is displayed can be sufficiently recognized even if the luminance is not so high, when it is light, what is displayed may not be recognized if the luminance is not high.

With regard to a light-emitting device, since the luminance varies in proportion to the current or the voltage for operating the element, if the luminance is required to be higher, the power consumption has to be increased accordingly. However, if the level of the luminance of light emission is adjusted to be so high, when it is dark, the display is much brighter than needed with the power consumption being unnecessarily large.

In order to provide for such a case, it is effective to provide a light-emitting device according to the present invention with a function to sense with a sensor the brightness of the environment and to adjust the luminance of light emission according to the degree of the brightness. More specifically, the luminance of light emission is made high

when it is light, while the luminance of light emission is made low when it is dark. As a result, a light-emitting device which can prevent the power consumption from increasing and which does not make the user feel fatigued can be realized.

It is to be noted that, as such a sensor for sensing the brightness of the environment, a CMOS sensor or a CCD (charge-coupled device) can be used. Such a CMOS sensor may be conventionally integrated on a substrate where a light emitting element is formed, or a semiconductor chip may be attached to the outside. Further, a semiconductor chip having such a CCD formed thereon may be attached to a substrate where a light emitting element is formed, or a part of the electric equipment having the light-emitting device as its display portion may be structured to be provided with the CCD or the CMOS sensor.

A control circuit for changing the current or the voltage for operating the light emitting element in response to a signal obtained by the sensor for sensing the brightness of the environment is provided, by which the luminance of light emission of the light-emitting element can be adjusted according to the brightness of the environment. It is to be noted that such adjustment may be made either automatically or manually.

It is to be noted that the structure of the present embodiment can be implemented in any electric equipment described in Embodiment 6.

In the active matrix type or the passive type of light-emitting device, the delay of a signal and the voltage drop due to a wiring resistance are reduced to thereby enhance the operating speed of the driver circuit portion and improve the homogeneity of the quality of the image in the pixel portion.

What is claimed is:

1. A light-emitting device, comprising:

a first substrate;

a luminous element provided over said first substrate;

a current control TFT provided over said first substrate;

a current supply line provided over said first substrate and connected with said luminous element via said current control TFT;

a second substrate;

a wiring for aiding said current supply line, said wiring for aiding said current supply line provided over said second substrate and electrically connected to said current supply line; and

a conductor for electrically connecting said current supply line and said wiring for aiding said current supply line,

wherein the luminous element is located between the first substrate and the second substrate.

2. A device according to claim **1**, wherein said luminous element is an EL element.

3. A device according to claim **1**, wherein said wiring for aiding said current supply line is made of a metallic film selected from the group consisting of copper, silver, gold, aluminum and nickel, or an alloy film containing as a main component a material selected from the group consisting of copper, silver, gold, aluminum, and nickel.

4. A device according to claim **1**, wherein said wiring for aiding said current supply line is formed into a layered structure made of a metallic film that is made of two or more different elements selected from copper, silver; gold, aluminum and nickel.

5. A device according to claim **1**, wherein said wiring for aiding said current supply line is formed on a front surface of said second substrate, on a back surface thereof; or in the interior thereof.

6. A device according to claim **1**, wherein a via hole that is covered by said wiring for aiding said current supply line is formed in said second substrate.

7. A light-emitting device, comprising:

a first substrate;

a luminous element provided over said first substrate;

a current control TFT provided over said first substrate;

a gate control wiring provided over said first substrate for transmitting a power source signal of a gate driver circuit, a clock signal or a start signal;

a second substrate;

a gate control auxiliary line provided over said second substrate and electrically connected to said gate control wiring;

a conductor for electrically connecting said gate control wiring and said gate control auxiliary line; and

a sealing agent for bonding said first substrate and said second substrate together,

wherein the luminous element is located between the first substrate and the second substrate.

8. A device according to claim **7**, wherein said luminous element is an EL element.

9. A device according to claim **7**, wherein said gate control auxiliary line is made of a metallic film containing a material selected from the group consisting of copper, silver, gold, aluminum and nickel, or an alloy film containing as a main component a material selected from the group consisting of copper, silver, gold, aluminum, and nickel.

10. A device according to claim **7**, wherein said gate control auxiliary line is formed into a layered structure made of a metallic film that is made of two or more different elements selected from copper, silver, gold, aluminum and nickel.

11. A device according to claim **7**, wherein said gate control auxiliary line is formed on a front surface of said second substrate, on a back surface thereof, or in the interior thereof.

12. A device according to claim **7**, wherein a via bole that is covered by said gate control auxiliary line is formed in said second substrate.

13. A light-emitting device, comprising:

a first substrate;

a luminous element provided over said first substrate;

a current control TFT provided over said first substrate;

a current supply line provided over said first substrate and connected with said luminous element via said current control TFT;

a second substrate;

a wiring for aiding said current supply line, said wiring for aiding said current supply line provided over said second substrate and electrically connected to said current supply line;

a conductor for electrically connecting said current supply line and said wiring for aiding said current supply line;

a sealing agent for bonding said first substrate and said second substrate together; and

a resin filled in a space between said first substrate and said second substrates,

wherein the luminous element is located between the first substrate and the second substrate.

14. A device according to claim **13**, wherein said luminous element is an EL element.

15. A device according to claim **13**, wherein said wiring for aiding said current supply line is made of a metallic film

containing a material selected from the group consisting of copper, silver, gold, aluminum and nickel, or an alloy film containing as a main component a material selected from the group consisting of copper, silver, gold, aluminum, and nickel.

16. A device according to claim **13**, wherein said wiring for aiding said current supply line is formed into a layered structure made of a metallic film that is made of two or more different elements selected from copper, silver, gold, aluminum and nickel.

17. A device according to claim **13**, wherein said wiring for aiding said current supply line is formed on a front surface of said second substrate, on a back surface thereof, or in the interior thereof.

18. A device according to claim **13**, wherein a via hole that is covered by said wiring for aiding said current supply line is formed in said second substrate.

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