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Seo et al.

(10) **Patent No.: US 7,728,513 B2**
(45) **Date of Patent: *Jun. 1, 2010**

(54) **DISPLAY DEVICE AND METHOD FOR MANUFACTURING THEREOF**

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(73) Assignee: **Semiconductor Energy Laboratory Co., Ltd.** (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 355 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/713,910**

(22) Filed: **Mar. 5, 2007**

(65) **Prior Publication Data**

US 2007/0200491 A1 Aug. 30, 2007

Related U.S. Application Data

(63) Continuation of application No. 10/345,745, filed on Jan. 16, 2003, now Pat. No. 7,199,516.

(30) **Foreign Application Priority Data**

Jan. 25, 2002 (JP) 2002-016524
Feb. 25, 2002 (JP) 2002-047379
Aug. 30, 2002 (JP) 2002-255216

(51) **Int. Cl.**
H01L 51/00 (2006.01)

(52) **U.S. Cl.** **313/504**; 313/506

(58) **Field of Classification Search** 313/504, 313/506

See application file for complete search history.

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Primary Examiner—Karabi Guharay
(74) *Attorney, Agent, or Firm*—Husch Blackwell Sanders LLP

(57) **ABSTRACT**

It is a problem to provide an electric apparatus less in consumption power and long in life by the manufacture using the display device. An insulating bank is provided in a form surrounding the pixel portions on first electrodes over a substrate. The entire surface is applied, by a wet scheme (method), with an organic conductive film which has a thickness form of T2>T1>T3> under the influence of the insulating bank. Accordingly, the portion T3 has an increased resistance in a lateral direction, making possible to prevent against crosstalk. Due to a conductive polymer as a buffer layer, a display device can be provided which is low in drive voltage. Furthermore, because the portion T2 is increased in thickness, the electric-field concentration is relaxed at and around the pixel portion. This makes it possible to prevent the organic light-emitting element from deteriorating at around the pixel.

27 Claims, 13 Drawing Sheets

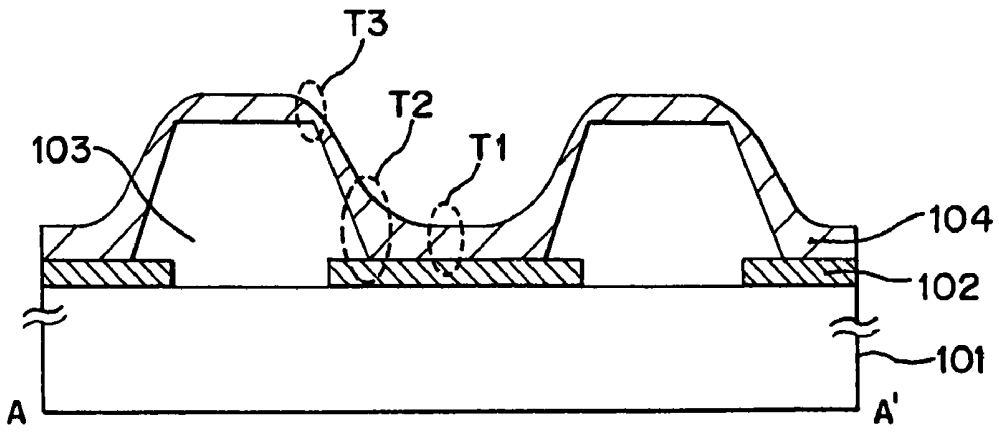

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FIG.1B

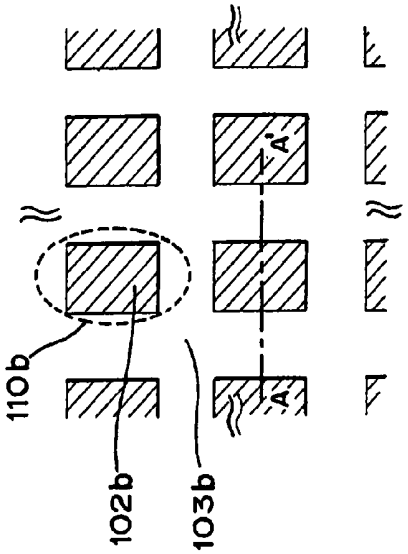


FIG.1A

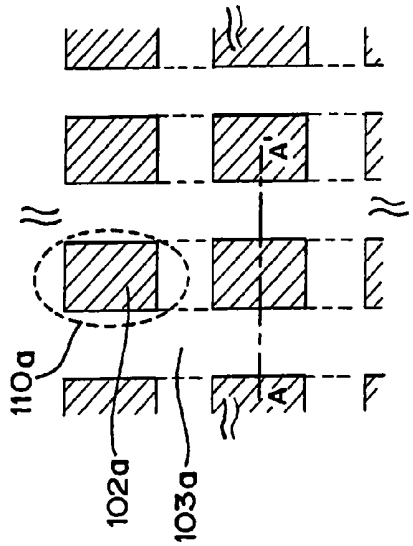
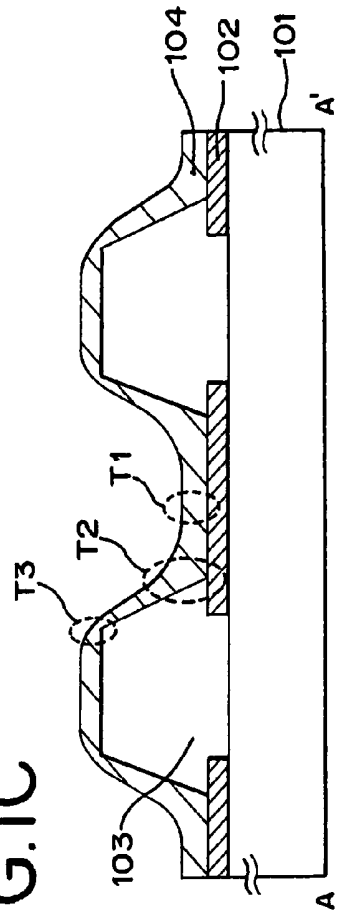


FIG.1C



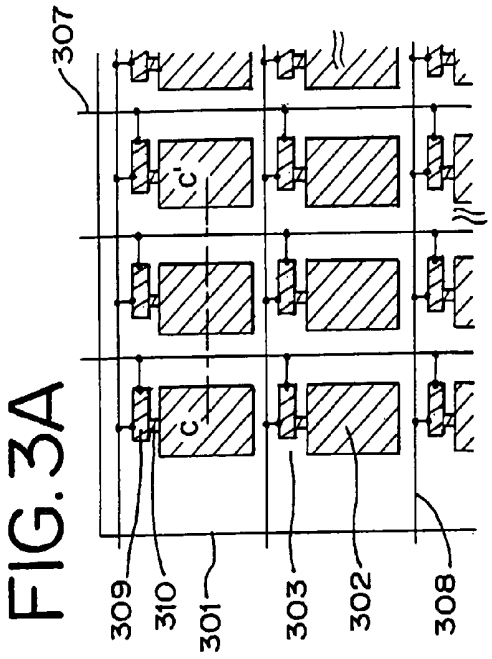


FIG.3A

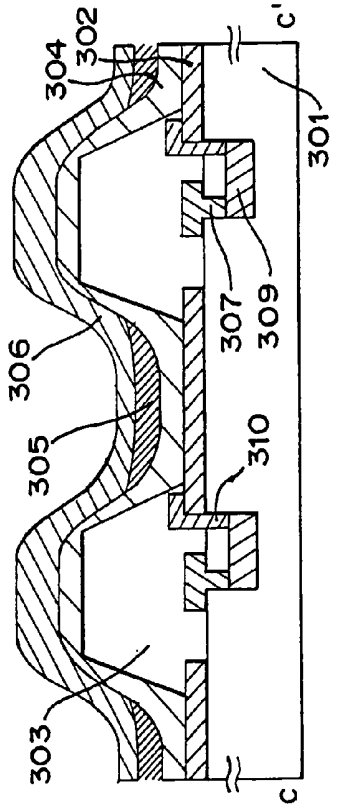


FIG.3B

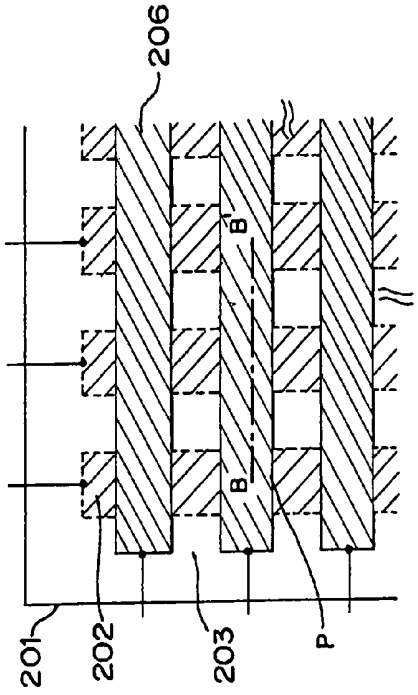


FIG.2A

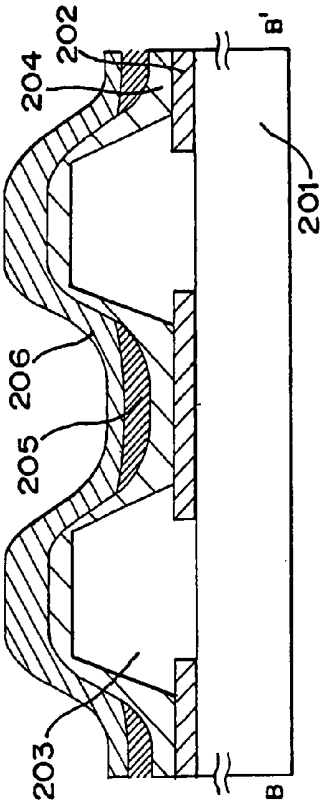
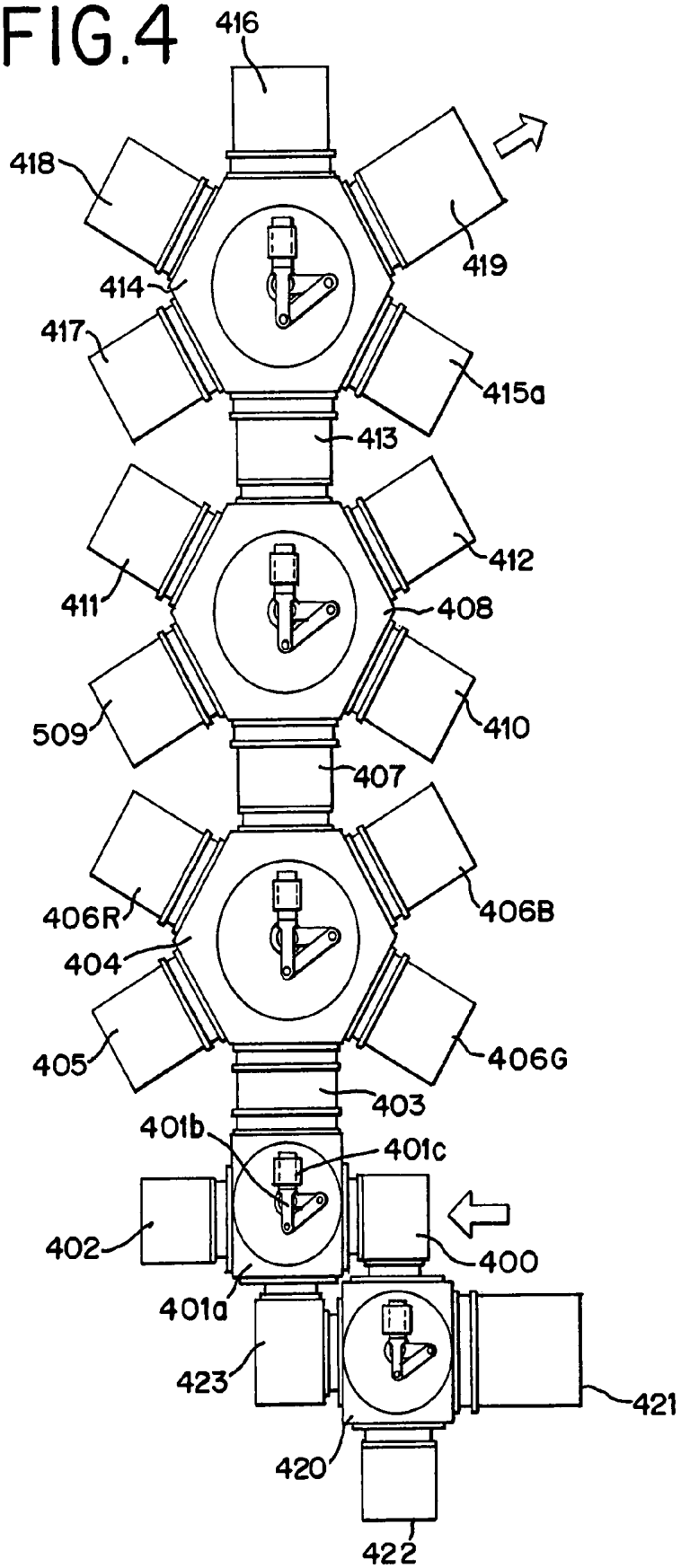


FIG.2B

FIG.4


416
418
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414
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415a
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412
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408
509
410
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406R
406B
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406G
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401b
401c
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401a
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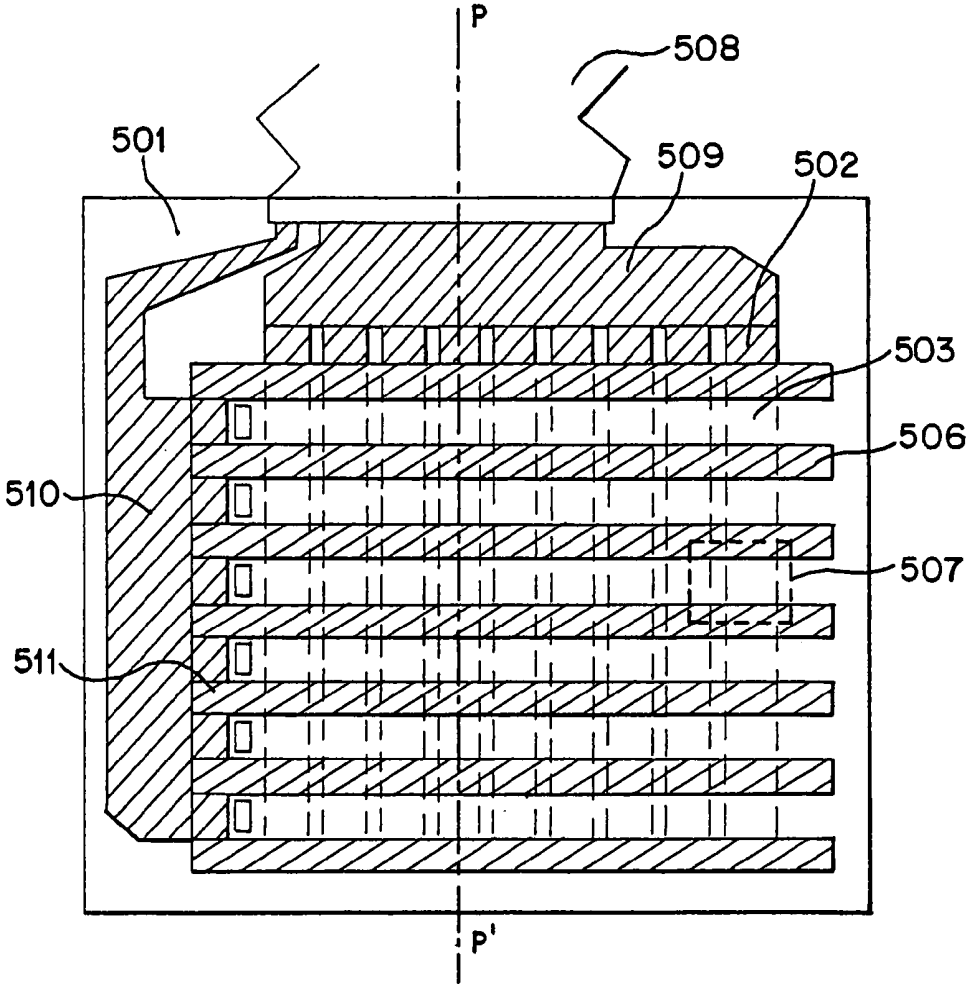
420
422

FIG.5A


P
508
501
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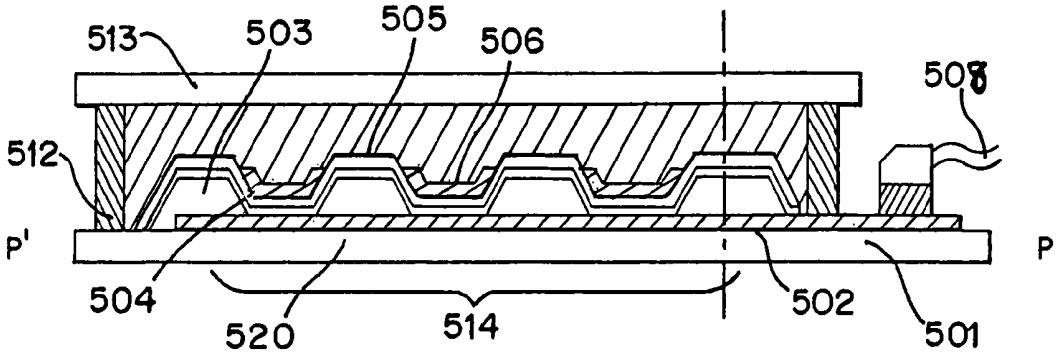
511
P'

FIG.5B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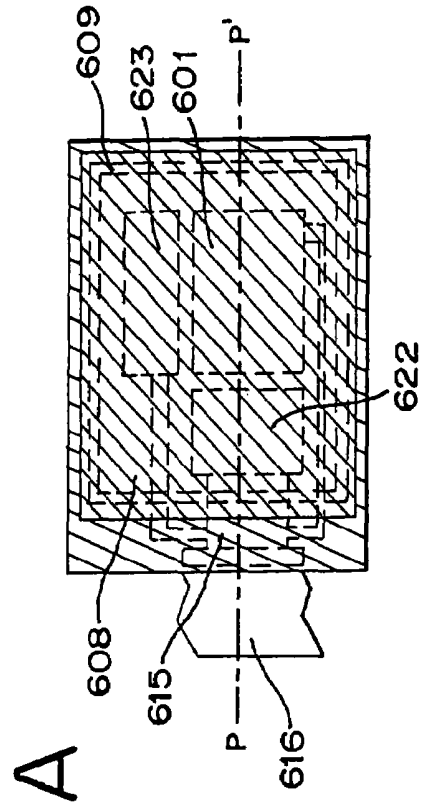
514
502
501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623
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P'
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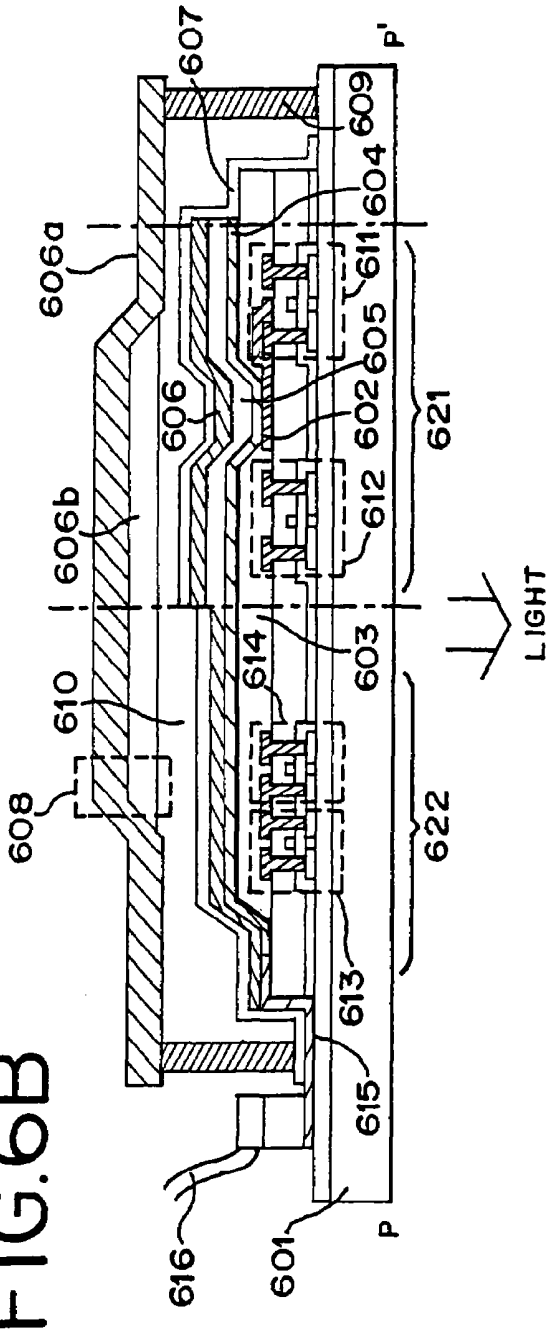
P
616

FIG.6A


607
609
P'
604
606a
611
605
606
602
621
606b
612
LIGHT
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614
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608
622
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615
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601
P

FIG.6B

FIG. 7

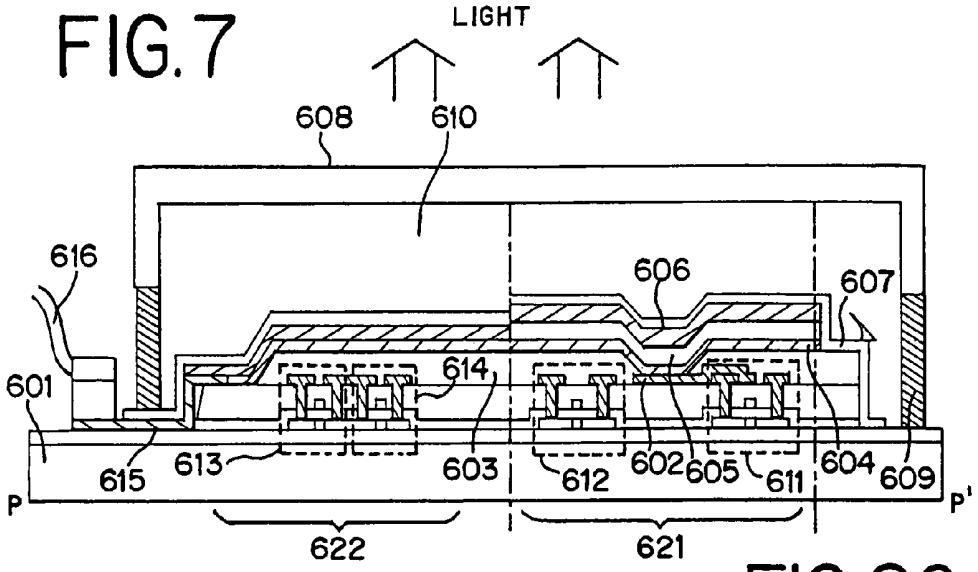


FIG. 8A

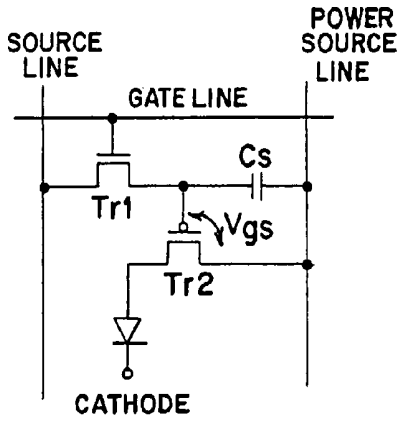


FIG. 8C

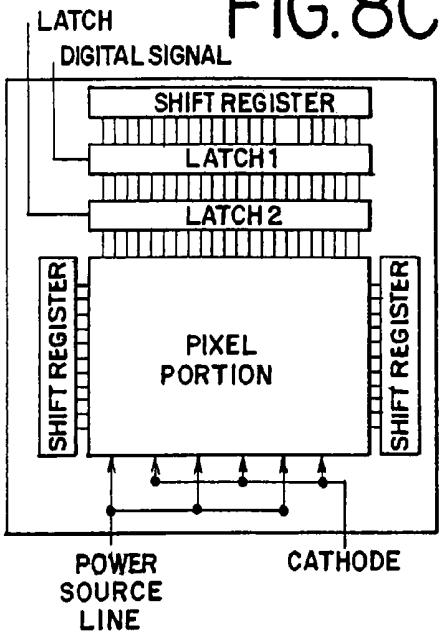
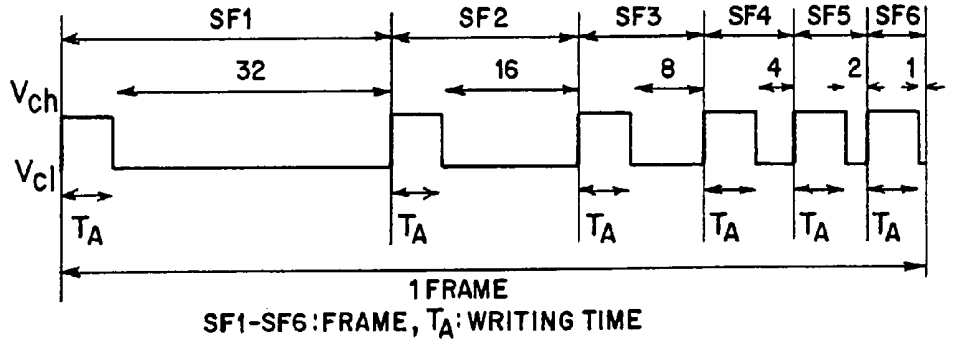


FIG. 8B



SF1-SF6 : FRAME, T_A : WRITING TIME

FIG.9A

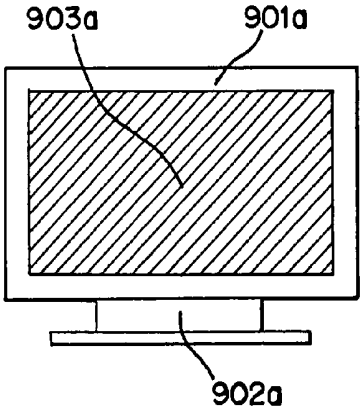


FIG.9B

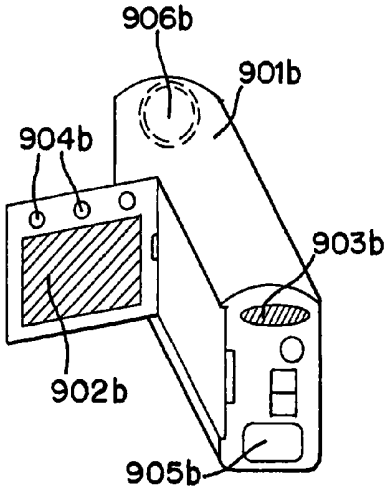


FIG.9C

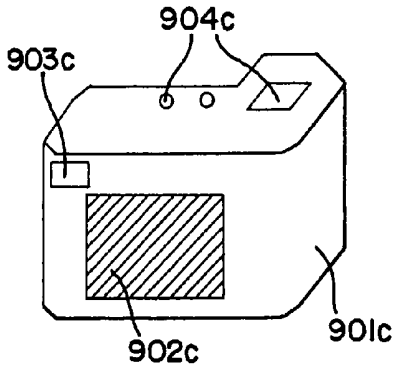


FIG.9D

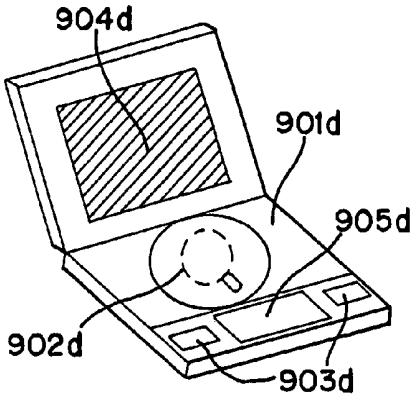


FIG.9E

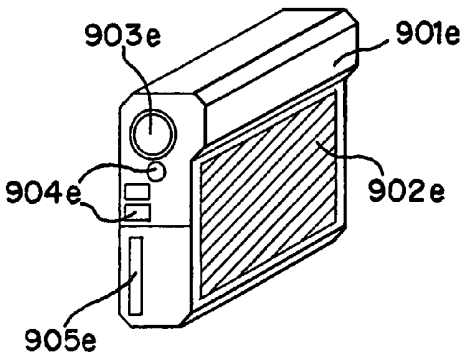


FIG.9F

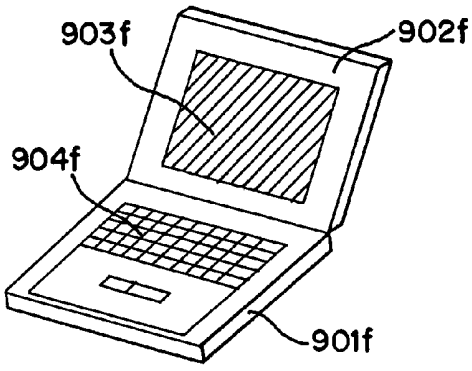


FIG.10A

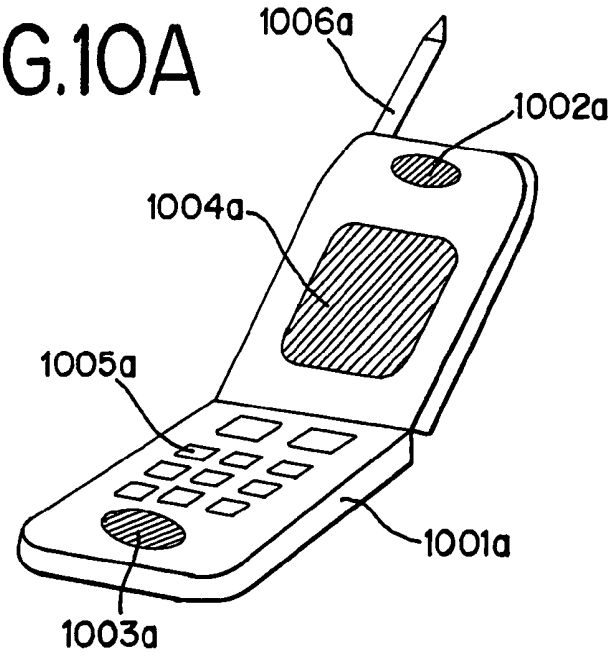


FIG.10B

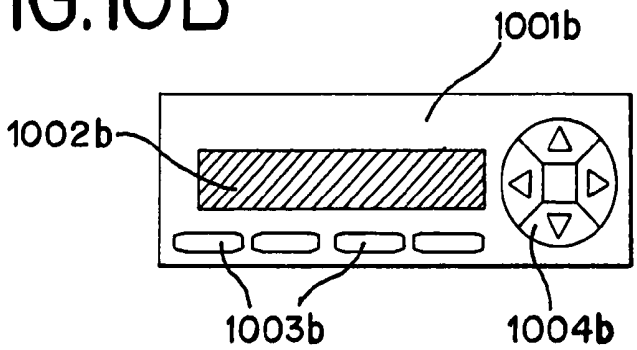


FIG.11

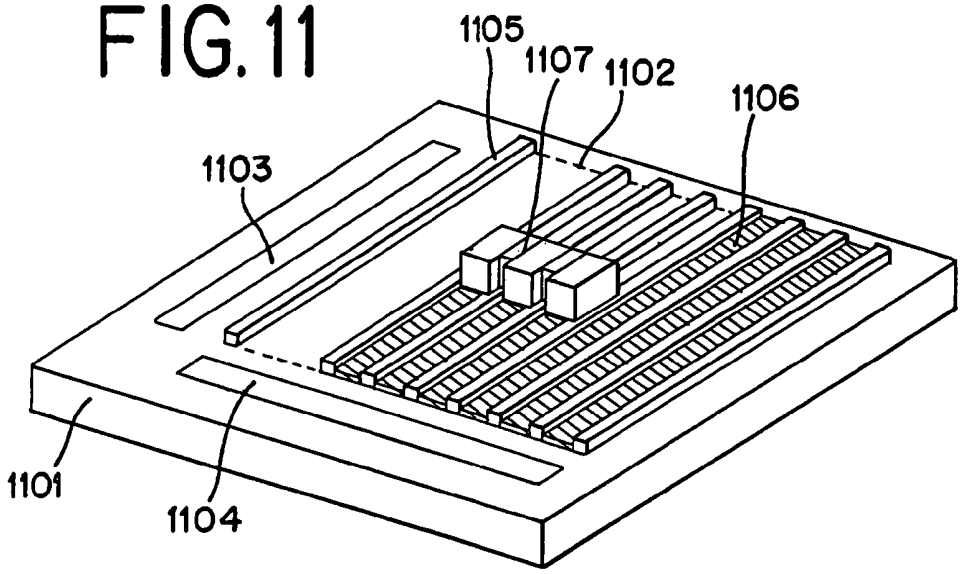


FIG.12A

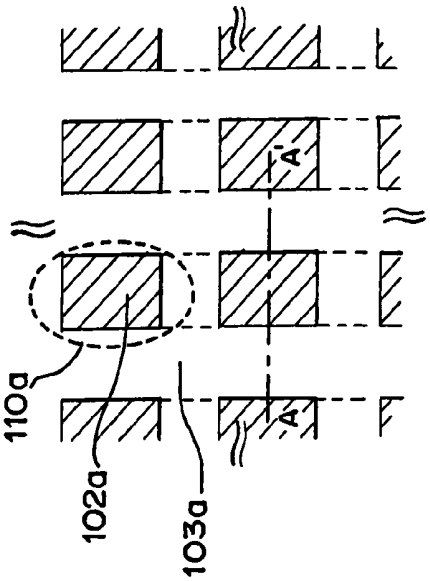


FIG.12B

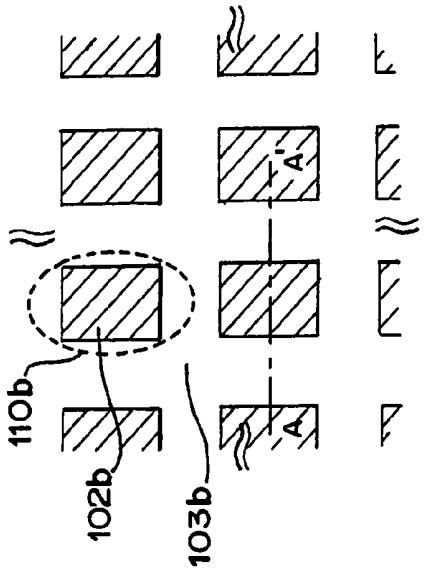


FIG.12C

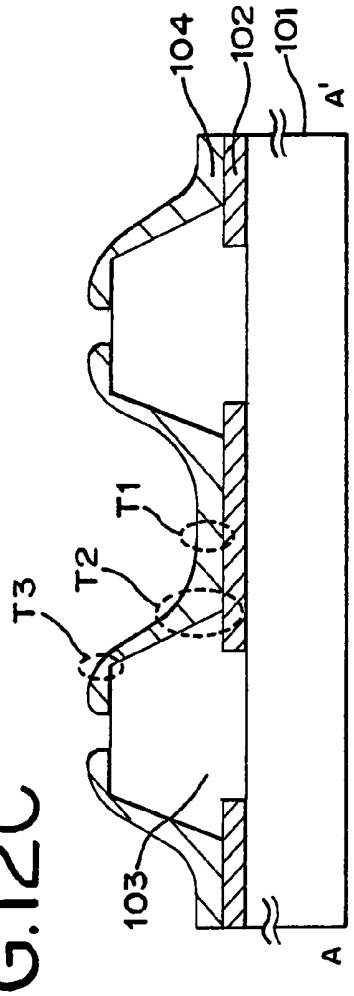


FIG.13A

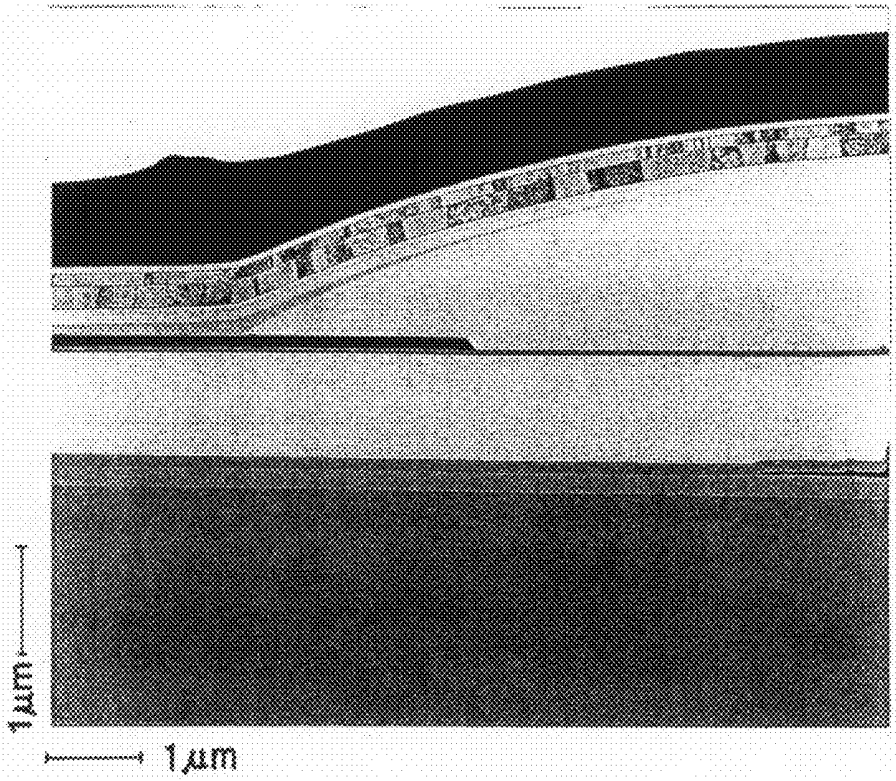


FIG.13B

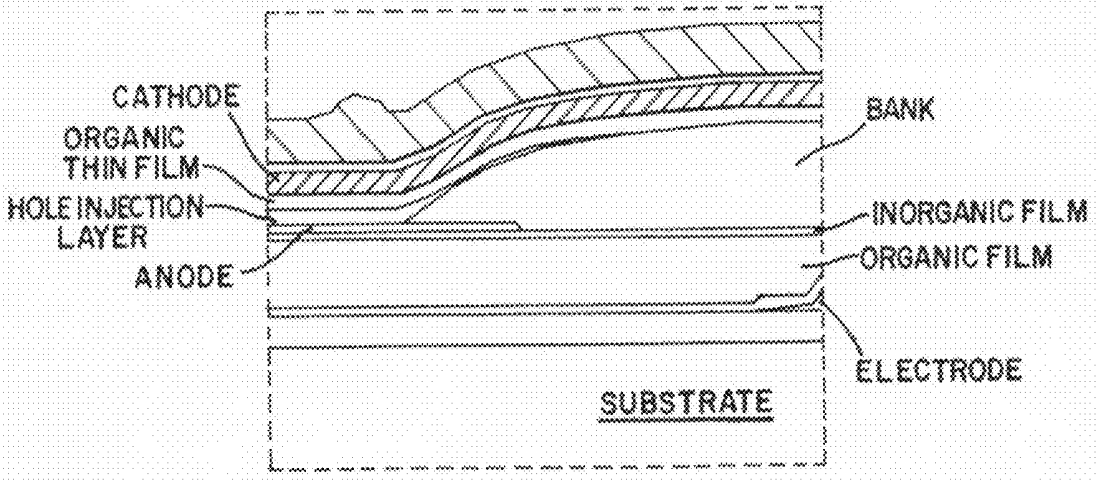


FIG.14A

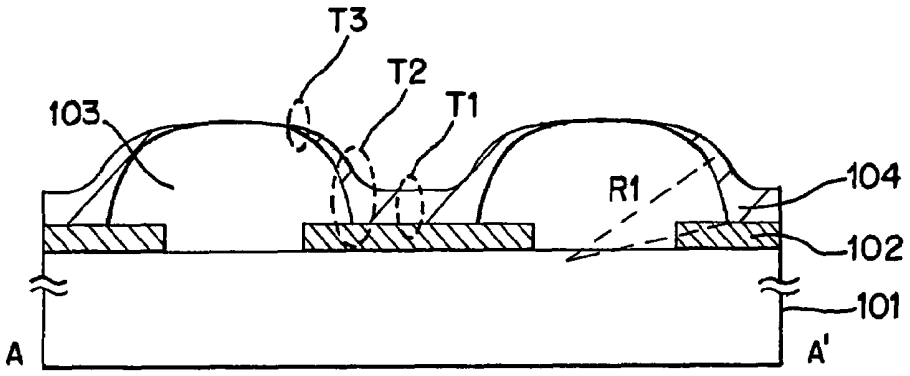


FIG.14B

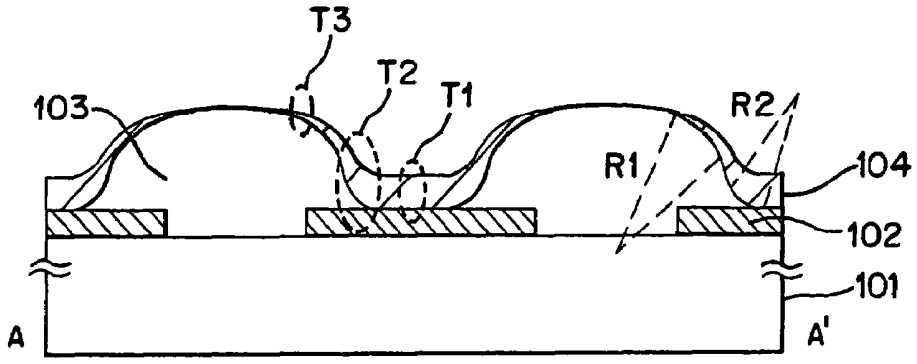
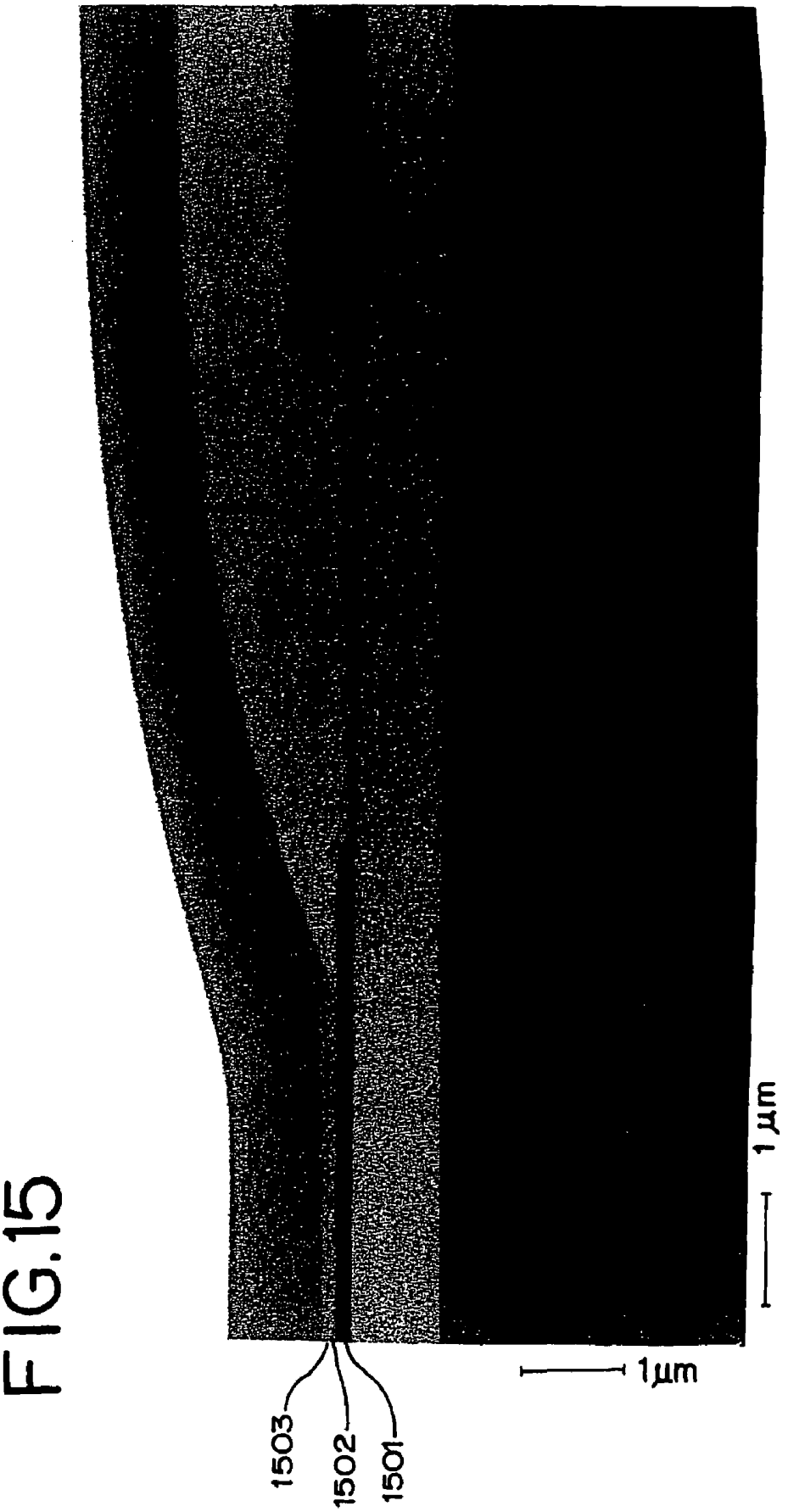


FIG.15



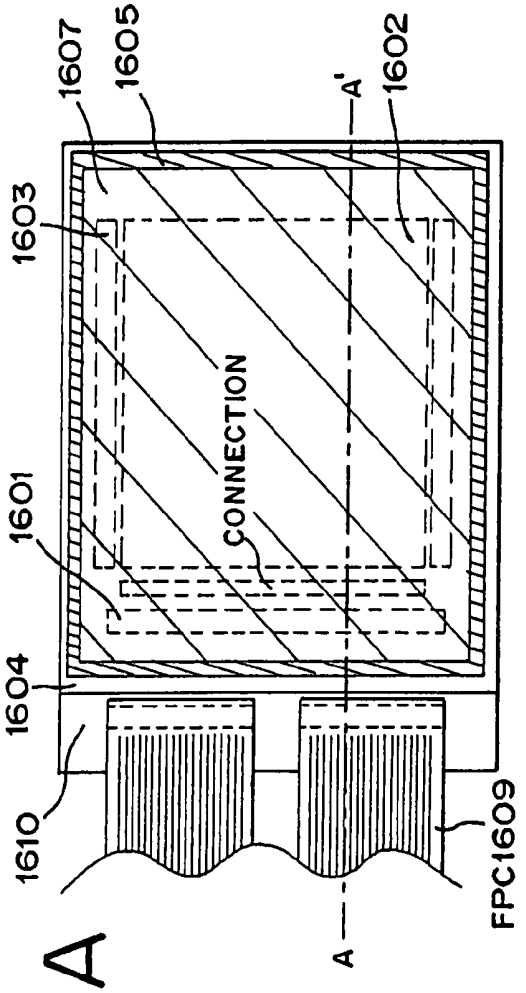


FIG.16A

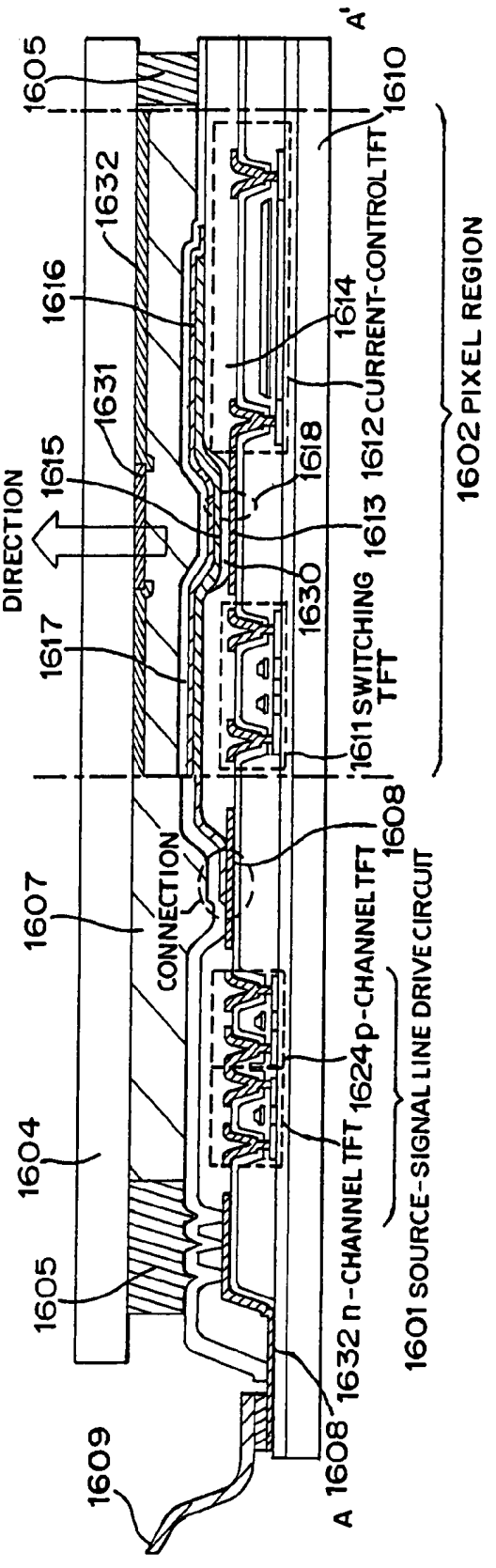


FIG.16B

DISPLAY DEVICE AND METHOD FOR MANUFACTURING THEREOF

This application is a continuation of U.S. application Ser. No. 10/345,745, filed on Jan. 16, 2003 (now U.S. Pat. No. 7,199,516 issued Apr. 3, 2007).

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a display device using an organic light-emitting device that has an anode, a cathode, and a film containing an organic compound that emits light by application of electric field (hereinafter referred to as organic thin film). Specifically, the present invention relates to a high reliable display device that drives at a low voltage. The organic thin film contains an organic compound as light-emitting compounds, and also may contain an inorganic compound as another component elements. The term display device in this specification refers to an image display device that employs the organic light-emitting device as a light-emitting device. Also included in the definition of the display device are: a module in which a connector, such as an anisotropic conductive film (FPC: flexible printed circuit), a TAB (tape automated bonding) tape, or a TCP (tape carrier package), is attached to the organic light-emitting device; a module in which a printed wiring board is provided on the tip of a TAB tape or a TCP; and a module in which an IC (integrated circuit) is mounted directly to the organic light-emitting device by the COG (chip on glass) method.

2. Description of the Related Art

The organic light-emitting device emits light when electric field is applied. Light emission mechanism thereof is said to be as follows. A voltage is applied to an organic thin film sandwiched between electrodes to cause recombination of electrons injected from the cathode and holes injected from the anode in the organic thin film and, the excited molecule (hereinafter referred to as molecular exciton) emits light resultingly with releasing energy when returns to base state.

There are two types of molecular excitons from organic compounds; one is singlet exciton and the other is triplet exciton. This specification includes both cases where singlet excitation causes light emission and where triplet excitation causes light emission,

In the organic light-emitting device such as the above, its organic thin film is usually formed to have a thickness of less than 1 μm. In addition, the organic light-emitting device does not need back light that is required in conventional liquid crystal displays since it is a self-light-emitting device in which light is emitted from the organic thin film by itself Therefore the great advantage of the organic light-emitting device is very thin and light-weight.

When the organic thin film having a thickness of about 100 to 200 nm, for example, recombination takes place within several tens nanoseconds after injecting carriers, based on the mobility of the carriers in the organic thin film. Considering the process from carrier recombination to light emission, the organic light-emitting device is readied for light emission in microseconds. Accordingly, quick response is also one of the advantages of the organic light-emitting device.

Since the organic light-emitting device is of carrier injection type, it can be driven with a direct-current voltage and noise is hardly generated. Regarding a driving voltage, a report says that a sufficient luminance of 100 cd/m^2 is obtained at 5.5 V by using a super thin film with a uniform thickness of about 100 nm for the organic thin film, choosing an electrode material capable of lowering a carrier injection barrier against the organic thin film, and further introducing the hetero structure (two-layer structure) (Reference 1: C. W. Tang and S. A. VanSlyke, "Organic electroluminescent diodes", Applied Physics Letters, vol. 51, no. 12, 913-915 (1987)).

It can be said that the organic light-emitting device demonstrated in Reference 1 is characterized by separation of functions of the hole transporting layer and the electron transporting light-emitting layer in which the former layer is assigned to transport holes and the latter layer is assigned to transport electrons and emit light. The idea of separation of functions has been developed to a double hetero structure (three-layer structure) in which a light-emitting layer is sandwiched between a hole transporting layer and an electron transporting (Reference 2: Chihiaya ADACHI, Shizuo TOKITO, Tetsuo TSUTSUI, and Shogo SAITO, "Electroluminescence in Organic Films with Three-Layered Structure", Japanese Journal of Applied Physics, vol. 27, No 2, L269-L271 (1988)).

An advantage of separation of function is an expansion of freedom in molecular design (for example, it makes unnecessary to make the effort to find bipolar materials) since it is unnecessary to give simultaneously various functions (luminescence, carrier transportation, and carrier injection from electrodes) to one kind of organic material. In other words, light luminescent efficiency can be obtained easily by combining materials excellent in luminescent characteristics with materials excellent in carrier transportation ability.

With respect to separation of function, conception of a cathode buffer layer and an anode buffer layer is suggested as an introduction of a function of carrier injection to reduce driving voltage,. There is a report that the driving voltage is reduced by enhancing injection of carrier by means of inserting materials that ease energy barrier into an interface between cathode and the organic thin film thereto (Reference 3: Takeo Wakimoto, Yoshinori Fukuda, Kenichi Nagayama, Akira Yokoi, Hitoshi Nakada, and Masami Tsuchida, "Organic EL Cells Using Alkaline Metal Compounds as Electron Injection Materials", IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL. 44, NO. 8, 1245-1248 (1997)), In Reference 3 it is disclosed that Wakimoto et ale succeeded to reduce driving voltage by using Li_2O as a cathode buffer layer.

With respect to a buffer layer, a buffer layer comprising polymer attracts especially attention in recent years (Reference 4; Yoshilaru Sato, Molecular Electronics and Bioelectronics (The Japan Society of Applied Physics), vol, 11, No. 1, 86-99 (2000)). In Reference 4 it is disclosed that using an anode buffer layer comprising polymer promotes the lower voltages, longer lifetime, and higher heat resistance. The anode buffer layer comprising polymer can be formed thick since the conductivity is increased by introducing appropriate accepter. Thus, it can contribute to flatness and is expected that it have an effect on decreasing short circuit.

With those features, including being thinner and lighter, quick response, and direct current low voltage driving, the organic light-emitting device is attracting attention as a next-generation flat panel display device. In addition, with being a self-light-emitting type and a wide viewing angle, the organic light-emitting device has better visibility and is considered as effective especially in using for a display screen of in-car products and portable equipments. Practically, the organic light-emitting device is used for a display screen of area color of in-car audio equipments.

Another feature of the organic light-emitting device is emission of light of various colors. The well varied colors are derived from the diversity of organic compounds of its own.

In other words, the various colors are derived from the flexibility, with which materials emitting different colors can be developed by designing a molecule (introduction of a substituent, for example).

From these points, it is safe to say that the most promising application field of organic light-emitting devices is in full color flat panel displays without mentioning mono color and area color displays. Various methods have been devised to display full color while considering the characteristics of organic light-emitting devices Currently, there are three major methods for manufacturing a full color display device using the organic light-emitting device. One of those major methods is to separately form the organic light-emitting device that emits red light, the organic light-emitting device that emits green light and the organic light-emitting device that emits blue light using a shadow mask technique. Red, green, and blue are the primary three colors of light, and each of the three types of organic light-emitting devices makes one pixel. This method is hereinafter referred to as an ROB method. Another one of the major methods obtains the primary three colors of light by using a blue organic light-emitting device as a light emission source and converting the blue light into green light and red light through color conversion layers that are formed of organic fluorescent materials. This method is hereinafter referred to as a CCM method The last one is a method of obtaining the primary three colors of light by transmitting white light from a white organic light-emitting device used as a light emission source through color filters that are used in liquid crystal display devices or the like. This method is hereinafter referred to as a CF method.

In any of these configuration, driving methods such as passive matrix driving (simple matrix type) and active matrix driving (active matrix type) are used for a display device that is formed by arranging the organic light-emitting devices as a matrix of pixels In addition, in the case that the pixel density is thickened, it is said that the active matrix type provided switches (for example, non-linear elements such as transistors) in each pixel has an advantage over the passive matrix type because it can drive at a low voltage.

Meanwhile, as mentioned previously the buffer layer comprising polymer as demonstrated in Reference 4 promotes lower driving voltage, longer lifetime, and higher heat resistance. A problem has arisen when the organic light-emitting device having a buffer layer (mainly anode buffer layer) comprising these materials is tried to apply by arranging into matrix of each pixel in the display device. The problem is crosstalk.

In most buffer layer comprising polymer, donor or accepter is added to its polymer comprising π conjugated system to give them-n conductivity The polymer is usually applied whole surface by spin coating and the like, and that leads to current leakage between polymer and wirings in places.

For example, it is reported that use of polyethylene dioxythiophene/polystyrene sulfonate (hereinafter referred to as "PEDT/PSS") that is conductive polymer added with accepter as an anode buffer layer for forming a passive matrix display device causes crosstalk (Reference 5: A, Elschner, F. Jonas, S, Kirchlmeyer, K, Wussow, "High-Resistivity PEDT/PSS for Reduced Crosstalk in Passive Matrix OELs", Asia Display/IDW '01, 1427-1430 (2001)). In Reference 5 it is described that resistivity of PEDT/PCC is made high on purpose to avoid crosstalk.

However, if the resistivity is made high, the buffer layer comprising polymer can not be formed to have a thick film (that is, current does not pass easily through the organic light-emitting device). Therefore, the characterization that avoid short circuit due to flattening of electrode surface by means of making the film thickening is lost. High resistivity leads to high driving voltage spontaneously. Thus, the advantage of low driving voltage is also lost.

SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to apply a conductive buffer layer using a polymer to a display device formed by arranging organic light-emitting elements as pixels in a matrix form without causing crosstalk Also, it is a problem to provide, by the above, a display device which is low in drive voltage, excellent in reliability and heat resistance, and less in defects of short circuits or the like.

Furthermore, it is a problem to provide an electric apparatus less in consumption power and long in life by the manufacture using the display device.

The present invention is a display device having a plurality of pixels arranged in a matrix form, comprising: a substrate; a plurality of first electrodes provided on a insulating surface of the substrate and corresponding to the plurality of pixels; an insulating bank surrounding the first electrode and protruding above a surface of the first electrode; an organic conductor film provided on the insulating bank and first electrode; an organic thin film provided on the organic conductor film and containing an organic compound capable of causing electroluminescent; and a second electrode provided on the organic thin film.

Particularly, the organic conductor film is characterized by comprising a high polymer added with an acceptor or donor. Furthermore, considering a flatness, the organic conductor film is preferably a film formed by a wet scheme. The wet scheme is suitably a spin coat process, ink jet process or spray process Incidentally, the organic conductor film preferably has a conductivity of 10^{-6} S/cm or higher and 10^{-2} S/cm or lower.

Meanwhile, the insulating bank is characterized by having a taper form gradually smaller toward the above of the substrate. In this case, the taper form preferably has a taper angle of 60 degrees or greater and 80 degrees or smaller. Furthermore, in the case that the insulating bank has a curved surface form having at least one center of a radius of curvature at the substrate side to the edge line of the insulating bank or in the case that the insulating bank has a curved surface form having at least one center of a radius of curvature at the substrate side to the edge line of the insulating bank and at least one center of a radius of curvature at the opposite side of the substrate side to the edge line of the insulating bank, spin application can be especially, suitably carried out.

Furthermore, in the invention, the display device is characterized by further including a data signal line, a scanning signal line and a nonlinear element connected to the data signal line, the scanning signal line and the first electrode. In this case, the nonlinear element is preferably formed by a combination of a mutually connected thin film transistor and capacitor or a combination of a thin film transistor and a parasitic capacitor to the thin film transistor.

Meanwhile, as long as being a display device, the display device satisfactorily has, in any surface, a transparency for a visible portion of light. Accordingly, the invention is characterized in that the substrate and the first electrode have a transparency for a visible portion of light, or otherwise the second electrode has a transparency for a visible portion of light.

As a manufacturing method for the foregoing display device, in the invention, the process for manufacturing a display device having a plurality of pixels arranged in a matrix form, comprising: a patterning step of forming a plu-

rality of first electrodes corresponding to the plurality of pixels, on an insulating surface of a substrate; a step of forming an insulating bank surrounding the first electrode and protruding above a surface of the first electrode; a step of providing an organic conductor film on the insulating bank and first electrode; a step of forming an organic thin film containing an organic compound capable of causing electroluminescent on the organic conductor film; and a step of forming a second electrode on the organic thin film.

In the invention, the step of providing the organic conductor film on the insulating bank and the first electrode is by a wet process. In this case the wet process is preferably a process to spray-apply, spin-apply or ink-jet-apply a material solution or material dispersion liquid for the organic conductor film.

Furthermore, in the invention, the patterning step is characterized by including a step to form a data signal line, a scanning signal line and a nonlinear element connected to the data signal line, the scanning signal line and the first electrode. In this case, the nonlinear element is preferably formed by a combination of a mutually connected thin film transistor and capacitor or a combination of a thin film transistor and a parasitic capacitor to the thin film transistor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A to **1**C are views representing a concept of the present invention:

FIG. **2**A, B are views showing a concept of a passive-matrix display device of the invention;

FIGS. **3**A, B are views showing a concept of an active-matrix display device of the invention;

FIG. **4** is a view showing a fabrication apparatus for an organic light-emitting device;

FIGS. **5**A, B are views showing an embodiment of a passive-matrix display device;

FIGS. **6**A, B are views showing an embodiment of an active-matrix display device;

FIG. **7** is a view showing an embodiment of an active-matrix display device;

FIGS. **8**A to **8**C are diagrams showing an embodiment of a drive method;

FIGS. **9**A to **9**F are views showing concrete examples of electric apparatus;

FIGS. **10**A, B are views showing concrete examples of electric apparatus;

FIG. **11** is a view showing a concept to continuously form a conductive polymer by an ink jet method;

FIGS. **12**A to **12**C are views showing a concept of the invention having continuously formed a conductive polymer by an ink jet method;

FIGS. **13**A, B are figures showing a sectional TEM photographic picture;

FIGS. **14**A, B are views representing a concept of the invention;

FIG. **15** is a view showing a sectional TEM photographic picture; and

FIGS. **16**A, B are views showing an embodiment of an active-matrix display device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

There is shown in FIG. **1** a concept view of the present invention. In FIG. **1**A, an insulating bank **103***a* is provided in a form surrounding the pixel portions **110***a* in order to form striped (vertically in the figure) first electrodes **102***a* and pixels **110***a*, over a substrate Meanwhile, In FIG. **1**B, an insulating bank **103***b* is provided in a form surrounding the pixels **110***b* in order to form island-formed first electrodes **102***b* and pixel portions **110***b*, on the substrate. In any case, the sectional view taken along line A-A' in the figure is given as in FIG. **1**C. **101** is the substrate, **102** is the first electrode, and **103** is the insulating bank.

Various methods are known to form such insulating banks, e.g. disclosed in JP-A-8-227276 (Document 6). Document 6 has a structure having a substrate formed with a plurality of first display electrodes on a surface, an electrical-insulating barrier wall surrounding the first display electrode and protruding above the substrate, a thin film of organic electroluminescent medium having at least one layer formed over the first display electrode in the barrier wall, and a second display electrode commonly formed over a plurality of electroluminescent medium thin films.

It is assumed, in this case, that the entire surface is applied, by a wet scheme(method), with an organic conductive film **104** as represented by a conductive polymer of PEDOT/PSS or the like Ill such a case, the organic conductive film **104** has a thickness form of T**2**>T**1**>T**3** under the influence of the insulating bank **103**. Accordingly, the portion T**3** has an increased resistance in a lateral direction, making possible to prevent against crosstalk Furthermore, because the portion T**2** is increased in thickness, the electric-field concentration is relaxed at and around the pixel portion. This makes it possible to prevent the organic light-emitting element from deteriorating at around the pixel.

This form is effectively available where applying an organic conductive film by a wet scheme. However, the form can be obtained similarly where forming an organic conductive film by a dry process of vacuum deposition or the like. Hence, dry and wet processes, in any, are effective in forming an organic conductor film **104**.

This concept, if applied to a passive-matrix type, provides a form as shown in FIGS. **2**A-B. FIG. **2**A is a top view while FIG. **2**B is a sectional view taken along line B-B' in FIG. **2**A. Namely, striped first electrodes **202** are formed over the substrate **201** and an insulating bank **203** is formed in a form protruding above the fist electrodes **202** and surrounding the pixels P. An organic conductive film **204** (representatively, conductive polymer) is provided, further forming an organic thin film **205** containing an organic compound capable of causing electroluminescence. Second electrodes **206** are formed on that, orthogonal to the first electrodes.

It is noted herein that the organic thin film **205** is separately applied on a pixel-by-pixel basis by a metal mask, showing a form suited for full-color display. Naturally, for a single color, solid application is usable instead of separate application.

Meanwhile, the concept, if applied to an active-matrix type, provides a form of FIGS. **3**A-B. FIG. **3**A is a top view while FIG. **3**B is a sectional view taken along line C-C' in FIG. **3**A. Namely, island-formed first electrodes **302** are formed over the substrate **301** and an insulating bank **303** is formed in a form protruding above the fist electrodes **302** and surrounding the pixels. An organic conductive film **304** is provided on that, further forming an organic thin film **305** containing an organic compound capable of causing electroluminescence. Second electrodes **306** are formed on that by the solid application.

Furthermore, there are provided data signal lines **307**, scanning signal lines **308** and non-linear elements **309** connected to the data signal lines **307** and scanning signal lines **308**. The non-linear element is connected to the first electrode **302** through a contact **310**. This allows to individually switch each pixel. The non-linear element **309**, representatively, is

formed by a combination of mutually connected thin-film transistor and capacitor or a combination of thin film transistor and parasitic capacitor to the thin-film transistor.

Incidentally, in FIGS. **2** and **3**, the organic thin film configuration may use a structure of known organic light-emitting element. Also, the first electrode and the second electrode, in any one, may possess a transparency for a visible portion of light. Where the first electrode is an anode, the second electrode may be a cathode. When the first electrode is a cathode, the second electrode may be an anode.

For the organic conductor film, suitably applied is an approach to provide a dark conductivity by doping an acceptor or donor to an organic semiconductor. Concerning film-forming process, there are included those for deposition by a dry process, e.g. vacuum deposition, and those for film forming by a wet process of spin coating or the like.

The organic conductor film to be formed by a dry process, as one example, is generally by a method to co-deposit a low-molecular organic semiconductor and an acceptor or donor. The organic conductor film, co-deposited by a p-type organic semiconductor and an acceptor, is preferable as a hole injection layer. The organic conductor film, co-deposited by an n-type organic semiconductor and a donor, is preferable as an electron injection layer.

The low-molecular p-type organic semiconductor includes 4, 4'-bis[N-(1-naphtyl)-N-phenyl-amino]-biphenyl (abbribiation: α-NPD) and aromatic amine compound, such as 4,4', 4"-tris(N,N-diphenyl-amino)-triphenylamine (abbriviation: TDATA) and 4,4',4"-tris[-(3-methylphlenyl)-N-phenyl-amino]-triphenylamine (abbreviation: MTDATA). The low-molecular n-type organic semiconductor includes metal complexes, such as tris(8-quinolinolato)aluminum (abbreviation: Alq_3) and bis[2-(2-hydroxyphenyl)-benzooxazolato]zinc (abbreviation: $Zn(BOX)_2$), oxadiazole derivatives, such as 2-(4-biphenyril)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole (abbreviation: PBD) and 1,3-bis[5-(p-tert-buthlylphenyl)-1,3,4-oxadiazole-2-il]benzene (abbreviation: OXD-7), triazole derivatives, such as 5-(4-biphenyril)-3-(4-tert-butylphenyl)-4-phenyl-1,2,4-triazole (abbriviation: TAZ) and 5-(4-biphenyril)-3-(4-tert-butylphenyl)-4-(4-ethylphenyl)-1,2,4-triazole (abbreviation: p-EtTAZ), and a phenanthoroline derivative such as bathophenanthroline (abbreviation: BPhen)● bathocuproine (abbreviation: BCP).

The example of those, serving effectively as an acceptor and to be evaporated, includes, representatively, those acting as a Lewis acid, such as TCNQ, TCE, DDQ, benzoquinone, 2,6-naphthoquinone, p-fluoranil, tetrachiorodiphenoquinone and nickelbisdiphenylgluoxim. The example of those, serving effectively as a donor and to be evaporated, includes, representatively, those acting as a Lewis base, such as metals strong in donor nature such as alkali and alkali earth metals besides such organic compounds as TTF, TTT, methylphenothiazine and N-isopropylcarbazole.

The organic conductor film to be deposited by a wet process generally includes, as an example, a method to wet-apply a solution mixing an acceptor or donor in a high polymer having π-conjugated system as represented by a conductive polymer compound. If well film formability, a low-molecular organic compound may be used instead of a high polymer. In also this case, the organic conductive film mixed with an acceptor is preferable as a hole injection layer while the organic conductive film mixed with a donor is preferable as an electron injection layer.

The high polymer having π-conjugated system includes, as examples, polyphenylene derivatives, polythiophene derivatives and poly(paraphenylenevinylene) derivatives besides such materials in practical use as poly(ethylenedioxythiophene) (abbreviation: PEDOT), polyaniline (abbreviation: PAni) and polypyrol.

Those listed in the above can be used as an acceptor or donor. However, by using an acceptor of water-soluble polymer such as polystrene sulfonic acid (PSS), wet application is possible in a water-solvent system. PEDOT/PSS and PAni/PSS are known, which are particularly effective for a hole injection layer.

In the meanwhile, the tapered insulating bank was explained on the example in FIGS. **1** to **3**. However, where the insulating bank is in another form, the effect can be obtained similar or greater. FIGS. **14** A-C shows typical views that the tapered insulating bank of FIG. **1**C is made in another form.

FIG. **14**A is on a case that the insulating bank **103**, at its end, is made in a curved form having one radius of curvature R**1** at an inward of the insulating bank **103**. In such a case, because the insulating bank at its end depicts an arc as shown in FIG. **14**A, it is easy to form a state of T**2**>T**1**>T**3**. Particularly, this provides a great effect in preventing against crosstalk, because T**3** decreases in thickness as nearing to the top end of the insulating bank.

FIG. **14**B is on a case that the insulating bank **103**, at its end, is made in a curved form having one radius of curvature R**1** at an inward of the insulating bank **103** and one radius of curvature R**2** at an outward of the insulating bank **103**. In such a case, because the insulating bank at its end depicts an S-form as shown in FIG. **14**B, it is also easy to form a state of T**2**>T**1**>T**3**. In this case, a great effect is provided in preventing against crosstalk, because T**3** decreases in thickness as nearing to the top end of the insulating bank.

The insulating bank form as shown in FIGS. **14**A-B are particularly effective in the case wet application is carried out by a spin coat process. This is because liquid is readily spread evenly during spin coating due to moderated end of the insulating bank.

Incidentally, in case hydrogen atoms or molecules are previously existed in the organic conductor film **104**, **204** or **304** by a hydrogen plasma or hydrogen ion doping and diffused by heating after forming an organic thin film **205** or **305**, in the event of causing unpaired bonds (or radicals) in the organic thin film **205** or **305** during driving-in, they can be repaired to prevent deterioration.

FIG. **4** shows a concept view of an apparatus for forming a display device of FIGS. **2** and **3**. The apparatus is based on an example to form an organic thin film by vacuum deposition. This is, mainly, constructed with a transport chamber to transport substrates, a delivery chamber to deliver substrates, a deposition chamber to form various thin films and a seal chamber to carry out sealing. Each chamber has an evacuation device to achieve a required vacuum or a device to produce a gas atmosphere such as N_2. The chambers are mutually connected through gate valves or the like. Substrate transport is by a transport robot.

At first, a substrate **401***c* (hereinafter merely refereed to as "substrate", though previously built with a pixel region, drive circuits, interconnections, electrodes, protection films, etc.) is placed into the load chamber **400** from the outside. Typically, TFTs are used in the pixel and drive-circuit regions.

The substrate **401***c* in the load chamber **400** is transported by a transport robot **401***b* into the transport chamber **401***a* and then to a pre-process chamber **402**. Typically, the substrate **401***c* is pre-processed by heating, O_2-plasma treatment or the like in the pre-process chamber **402**. The pre-process aims at improving the characteristics of an OLED. This also serves to make a substrate application surface hydrophilic and improve

its wettability when a water-soluble conductive polymer or the like is to be applied for an organic conductor film.

The substrate completed of pre-process is again returned to the load chamber where it is subjected to nitrogen purge. Then, the substrate is transported to a transport chamber **420** under normal pressure (nitrogen atmosphere), and it is inverted to the normal position within an inversion chamber **422**. Then, an organic conductive film (specifically, conductive polymer such as PEDOT/PSS) is applied within an application chamber **421**. Although the method of application includes spin coating or dip coating, film-forming herein is by a spray technique. After application, the substrate is transported to an inversion-and-vacuum bake chamber **423** via the transport chamber **420**. In this chamber, inversion and vacuum bake are carried out.

In this manner, vacuum bake herein is carried out in an inverted state (i.e. in a face-down state that the substrate surface directed down). However, it is known that the relationship of T**2**>T**1**>T**3** mentioned in FIGS. **1**A-C or **14**A-B can be held without a problem when carrying out baking in a face-down state (referred later in Embodiment 8).

After vacuum baking, the substrate is transported to a transport chamber **404** through the transport chamber **401***a* and delivery chamber **403**. In the transport chamber **404**, a transport robot, mounted therein, plays a role to transport substrates to each of the chambers connected to the transport chamber **404**. The transport chamber **404** is connected with a deposition chamber for the purpose of forming organic layers Deposition chambers **406**R, **406**G, **406**B are set up to form RGB-colored light-emitting layers, in prospect of fabricating a full-color OLED display device. Furthermore, a deposition chamber **405** is set up in order to form a layer common to the colors, i.e. a carrier transport layer and carrier injection layer. These deposition chambers generally use a vacuum deposition process. In order to obtain full-color light emission, deposition may be carried out by the use of shadow masks for separate application such that the light-emitting layers for emitting RGB light are arranged in a stripe, mosaic or delta form. Incidentally, in the case of applying an organic conductive material onto the entire surface by a spin-coat or dip-coat process, prior to depositing organic layers, an O_2-plasma process is carried out combined with a mask in the pre-process chamber **402**. This can remove away an unwanted portion of the organic conductor film (region to be applied by a sealing agent or over the interconnections).

The substrate, after completed of organic layer deposition, is transported to a transport chamber **408** via a delivery chamber **407**. In the transport chamber **408**, a transport robot, mounted therein, plays a role to transport substrates to each of the chambers connected to the transport chamber **408**. The transport chamber **408** is connected with a deposition chamber for the purpose of forming a backside electrode or protection film. In the deposition chamber **409**, a metal for electrodes (e.g. AlLi alloy or MgAg alloy) is evaporated by a vacuum evaporation process or EB process. In a deposition chamber **411**, a transparent conductive film (e.g. ITO or IZO) required for light emission at a top surface of the substrate is deposited generally by a sputter process or chemical vapor deposition (CVD) process. In a deposition chamber **412**, a passivation film (e.g. SiN or SiOx film) for surface protection is deposited generally by a sputter process or CVD process.

The substrate completed of film forming is transported to a transport chamber **414** via a delivery chamber **413**. The transport chamber **414** is connected with a plurality of chambers required for sealing. In the transport chamber **414**, a transport robot mounted therein plays a role to transport substrates or sealed substrates to each chamber connected to the transport chamber **414**.

At first, there is a necessity to prepare substrates for sealing. For this purpose, there is provided a sealing glass substrate preparatory chamber **415***a* and sealing plastic substrate preparatory chamber **418**.

In the sealing glass substrate preparatory chamber **415***a*, a counter glass is placed from the outside to carry out glass-seal on the fabricated OLED. If necessary, a desiccant for preventing the OLED against moisture can be placed on the counter glass. For example, a sheet-formed desiccant may be bonded to a spot-faced part previously formed in the counter glass by a double-sided tape or the like.

On the other hand, in the sealing plastic substrate preparatory chamber **418**, preparation is made to plastic-seal the fabricated OLED. The operation may be fully automated, or partly manual by providing globes.

The prepared seal glass or plastic substrate is transported to a dispenser chamber **416** where it is applied by an adhesive (not shown) for later bonding with the substrate. This embodiment uses a UV-set adhesive. If necessary, the desiccant for preventing the OLED against water (not shown) may be reserved within the dispenser chamber **416**, instead of during placing a glass in the seal glass substrate preparatory chamber **415***a*. For example, a sheet-formed desiccant can be bonded on a previously formed spot-faced part of a counter glass by a double-sided tape or the like. This eliminates the necessity to handle a desiccant in the air. The operation may be fully automated, or partly manual by providing globes. Particularly, where the seal plastic substrate has a curvature and elasticity, an adhesive may be applied in a curved state or in a straightly stretched state.

The substrate completed of deposition and the seal glass or plastic substrate applied with an adhesive are transported into a seal chamber **417**, where these are bonded together. During bonding, there is a need to apply pressure by the use of a suitable jig (not shown). In the case of a seal plastic substrate having a curvature and elasticity, bonding may be done in a state straightly stretched state. The operation may be fully automated, or partly manual by providing globes.

Then, the substrate and seal substrate bonded together in the seal chamber **417** is transported into a UV-radiation chamber **18** where a UV ray is radiated to cure the adhesive.

The substrate and seal substrate bonded in the UV radiation chamber **418** may be taken out of a delivery chamber **419**.

Embodiment 1

This embodiment exemplifies a passive matrix display device by taking the display device for instance that is disclosed in the present invention. FIG. **5**A shows a top view thereof and FIG. **5**B shows a sectional view taken along the line P-P' of FIG. **5**A.

In FIG. **5**A, reference numeral **501** denotes substrate, a plastic material and glass are used for forming the substrate. As the plastic material, polyimides, polyamides, acrylic resins, epoxy resins, PESs (polyethersulfones), PCs (polycarbonates), PETs (polyethylene terephthalates), or PENs (polyethernitriles) can be used in state of a sheet or a film.

Reference numeral **502** denotes scanning lines (anodes) formed from a conductive oxide film The conductive oxide film used in this embodiment is obtained by indium tin oxide (ITO) that is transparent to the visible light Denoted by reference numeral **506** are data lines (cathodes) comprising of a metal film. The data lines are formed of stripe patterns by using CaF_2\Al electrode. Reference numeral **503** denotes an

insulating bank formed from an acrylic resin. The scanning lines **502** and the data lines **506** are respectively formed of stripe patterns. The two patterns cross each other at right angles. Though not shown in FIG. **5**A, conductive polymer (PEDOT/PSS) **504** and organic thin film **505** are sandwiched between the scanning lines **502** and the data lines **506**. Intersection units **507** serve as pixels.

The scanning lines **502** and the data lines **506** are connected to external driving circuits through a TAB tape **508**. Reference numeral **509** denotes a group of wiring lines that is a mass of the scanning lines **502**. **510** denotes a group of wiring lines that is a mass of connection wiring lines **511** connected to the data lines **506**. Though not shown, a TCP that is obtained by mounting an IC to a TAB tape may be connected instead of the TAB tape **508**.

In FIG. **5**B, **512** denotes a seal member, and **513** denotes a cover member bonded to a substrate **501** by the seal member **512**. A photo-curable resin can be used for the seal member **512**. It is preferred that the sealing member **512** is made of a material that hardly allows degassing and absorbs moisture. The cover member is preferably the same material as the substrate **501** and may be formed from glass (including quartz glass) or plastic. A glass is used here.

The light-emitting device of the present invention configured with above mentioned components can be manufactured by a very simple process since the pixel unit is composed of the scanning lines **502**, the data lines **506**, the insulating bank **503**, the conductive polymer **504**, and the organic thin film **505**.

A polarizing plate may be provided on a display screen (on which an image is viewed) of the display device demonstrated in this embodiment. The polarizing plate has the effect of minimizing the reflection of light entering the display screen from outside to prevent a viewer from reflecting on the display screen. A circular polarizing plate is used in general. However; it is preferred that the display device has the configuration that hardly causes internal reflection by adjusting the refractive index to prevent the light radiated from the organic thin film from returning to the interior due to reflecting by the polarizing plate.

Embodiment 2

In this embodiment an explanation will be given of a display device comprising the organic light-emitting device disclosed in the present invention. FIG. **6** is a diagram illustrating an active matrix type display device. The FIG. **6**A illustrates a view of top surface. FIG. **6**B illustrates a cross sectional view of FIG. **6**A taken along the line P-P'.

Note that although thin film transistors (referred to as TFTs hereinafter) are used as active devices in this embodiment, MOS transistors may also be used. Additionally, although top gate type TFTs (practically planar type TFTs) will be exemplified as the TFTs, bottom gate type TFTs (typically, inversely staggered TFTs) is alternatively used.

With reference to FIGS. **6**A-B, reference numeral **601** denotes a substrate. In order to observe the light through the substrate in the display device, the substrate must be transparent to the visible light. Practically, a glass substrate, a quartz substrate, a crystallized glass substrate or plastic substrate (including a plastic film) may be used. Note that the substrate **601** includes an insulating film provided on the surface thereof.

A pixel unit **621** and a drive circuit **622** are provided on the substrate **601**. The pixel unit **621** will first be explained below.

The pixel unit **621** is a region that performs image displaying. A plurality of pixels are formed on the substrate, each pixels is provided with a TFT **611** for control of a current flowing in an organic light-emitting device (referred to hereinafter as current controlling TFT), a pixel electrode (anode) **602**, a conductive polymer film **604**, an organic thin film **605**, and a cathode **606**. Each pixel is surrounded with the insulating bank **603**. In addition, numeral **612** denotes a TFT for controlling a voltage applied to the gate of the current controlling TFT (referred to as switching TFT hereinafter).

Both n-channel type TFT and p-channel type TFT may be used for the current controlling TFT **611**. However, it is preferable to use p-channel TFT here since it is superior in suppressing consumption of electrical power in case the current controlling TFT is connected to the anode of the organic light-emitting device as illustrated in FIGS. **6**A-B. Note however that the switching TFT may be either n-channel TFT or p-channel TFT.

It is noted that drain of the current controlling TFT **611** is electrically connected with the pixel electrode **602**. In this embodiment the pixel electrode **602** functions as the anode of the organic light-emitting device since a conductive material having a work function within a range of 4.5 to 5.5 eV is used for forming the pixel electrode **602**. The pixel electrode **602** may typically be made of materials having transparency to the light such as indium oxide, tin oxide, zinc oxide, or compounds thereof (such as ITO). The conductive polymer **604** and the organic thin film **605** are formed on the pixel electrode **602**.

Further, the cathode **606** is formed on the organic thin film **605**. It is desirable that a conductive material having a work function ranging from 2.5 to 3.5 eV is used for forming the cathode **606**. The cathode **606** is typically made of a conductive film containing alkaline metal elements or alkali rare metal elements, a conductive film containing aluminum, and one that aluminum or silver is laminated on the above conductive films.

A layer comprising the cathode **606** is covered by a protection film **607**. The protection film **607** is formed in order to prevent oxygen and water from penetrating into the organic light-emitting device. As materials for forming the protection film **607**, silicon nitride, silicon oxynitride, aluminum oxide, tantalum oxide, or carbon (typically diamond like carbon) may be used. Especially in the case that diamond carbon is used for the protection film **607**, hydrogen atom is contained in the protection film **607**. As mentioned above, diffusion of hydrogen atom into the organic thin film by heating is helpful in preventing degradation of the organic thin film by terminating dangling bond (or radical) that is generated in the organic thin film during driving.

An explanation will next be given of the drive circuit **622**. The drive circuit **622** is the region that controls the timing of signals (gate signal and data signal) being sent to the pixel unit **621**, which is provided with a shift register, a buffer, a latch, an analog switch (transfer gate), or a level shifter. In FIGS. **6**A-B a CMOS circuit is shown which is formed from an n-channel TFT **613** and p-channel TFT **614** for use as a basic unit of these circuits.

The circuit structure of the shift register, the buffer, the latch, the analog switch (transfer gate) or the level shifter may be designed to have a configuration that has become publicly known. Additionally although in FIGS. **6**A-B the pixel unit **621** and the drive circuit **622** are provided on the same substrate, it is also possible to electrically connect IC and LSI without providing the drive circuit **622**.

Reference numeral **623** denotes a gate signal line drive circuit, and **622** denotes a data signal line drive circuit. A signal is transmitted from the TAB (Tape Automated Bonding) tape **616** to the gate signal line drive circuit **623** and the

data signal line drive circuit **622** through an input wiring **615**. Though not shown, a TCP (Tape Carrier Package) that is obtained by mounting an IC (Integrated Circuit) to a TAB (Tape Automated Bonding) tape may be connected instead of the TAB tape **616**.

Reference numeral **608** denotes a cover member coated on top of the display device by sealing member **609** comprising of resin. For the cover member **608** any material can be used, provided that the materials do not allow oxygen and water to be penetrated. The cover member is comprised of a glass **608***a* having a depression and drying agent **608***b*. Thus, the organic light-emitting device is completely sealed into enclosed space **610** by the sealing member **609** The enclosed space **610** may be filled up with inert gas (typically nitride gas or noble gas), resin, or inert liquid (for example liquid fluorocarbon such as perfluoroalkane). In addition, it is effective to put absorbent and deoxidant into the enclosed space **610**.

In FIGS. **6**A-B it is illustrated that the pixel electrode (anode) **602** is electrically connected to the current control TFT **611**. However, the display device can be formed in a configuration in which the cathode is connected to the current control TFT. In that case same material for forming the cathode **606** may be used to the pixel electrode, and the same material for forming the pixel electrode (anode) **602** may be used to the cathode. This case requires that the current control TFT may be n-channel TFT.

A polarizing plate may be provided on a display screen (on which an image is viewed) of the display device demonstrated in this embodiment. The polarizing plate has the effect of minimizing the reflection of light entering the display screen from outside to prevent a viewer from reflecting on the display screen. A circular polarizing plate is used in general. However, it is preferred that the display device has the configuration that hardly causes internal reflection by adjusting the refractive index to prevent the light radiated from the organic thin film from returning to the interior by reflecting by the polarizing plate.

Embodiment 3

This embodiment exemplifies an active matrix display device by taking the display device for instance. In this embodiment the display device having a configuration in which light is emitted through the opposite substrate attached active devices (hereinafter referred to as top emission) is demonstrated, which is different from the configuration illustrated in Embodiment 2. FIG. **7** shows a sectional view thereof.

Note that although thin film transistors (referred to as TFTs hereinafter) are used as active devices in this embodiment, MOS transistors may also be used. Additionally, although top gate type TFTs (practically planar type TFTs) will be exemplified as the TFTs, bottom gate type TFTs (typically. inversely staggered TFTs) is alternatively used.

In this embodiment, except a first electrode, a second electrode, a protection film, and cover, member may have the same structures as those illustrated in Embodiment 2.

Since the first electrode **602** connected to the current control TFT **611** is used as an anode in this embodiment, a conductive material having a large work function is preferably used for the electrode. Typical examples of the conductive material include metals such as nickel, palladium, tungsten, gold, and silver. In this embodiment, the first electrode **602** is preferably not transparent to the light and, more preferably, is comprised of high reflective materials as well.

Since the top emission structure is exemplified here, it is based on the assumption that the second electrode **606** used in the display device having a transparency to light. Thus, the second electrode **606** is preferably formed to be a super thin film having a thickness of 20 nm when a metal is used to the second electrode **606**.

The protection film **607** is formed to protect the organic light-emitting device from oxygen and water. In this embodiment any material can be used for the protect film, provided that it is transparent to light.

Reference numeral **608** denotes a cover member that is bonded by sealing member **609** comprising of resin. For the cover member **609** any material can be used, provided that the materials do not allow oxygen and water to be penetrated and is transparent to light. A glass is used to the cover member in this embodiments. The enclosed space **610** may be filled up with inert gas (typically nitride gas or noble gas), resin, or inert liquid (for example liquid fluorocarbon such as perfluoroalkane). In addition, it is effective to put absorbent and deoxidant into the enclosed space **610**.

In FIG. **7** it is illustrate that the first electrode (anode) **602** is electrically connected to the current control TFT **611**. However the display device can be formed in a configuration in which the cathode is connected to the current control TFT In that case same material for forming the cathode may be used to the first electrode, and the same material for forming the anode may be used to the second electrode. This case requires that the current control TFT may be n-channel TFT.

Embodiment 4

This embodiment shows an example of a display device as is shown in Embodiment 2 or 3 that is driven in accordance with digital time gray scale display.

FIG. **8**A shows the circuit structure of a pixel that uses an organic light-emitting device. Tr represents a transistor and Cs represents a storage capacitor. In the circuit structure of FIG. **8**A, a source line is connected to source side of transistor Tr**1**, and a gate line is connected to gate side of transistor Tr**1**. A power source line is connected to source side of storage capacitor Cs, and transistor Tr**2**, Since anode of the organic light-emitting device of the present invention is connected to the side of the drain of transistor Tr**2**, cathode is formed at the opposite side of transistor Tr**2** across the organic light-emitting device.

In this circuit, when a gate line is selected, a current flows into Tr**1** from a source line and a voltage corresponding to the signal is accumulated in Cs. Then, a current that is controlled by the gate-source voltage (V_{gs}) of Tr**2** flows into Tr**2** and the organic light-emitting device.

After Tr**1** is selected, Tr**1** is turned OFF to hold the voltage (V_{gs}) of Cs. Accordingly, a current continues to flow in an amount dependent of V_{gs}.

FIG. **8**B illustrates a chart for driving this circuit in accordance with digital time gray scale display. In digital time gray scale display, one frame is divided into plural sub-frames. FIG. **8**B illustrates 6 bit gray scale in which one frame is divided into six sub-frames. TA represents writing periods. In this case, the ratio of light emission periods of the sub-frames is 32:16:8:4:2:1.

FIG. **8**C schematically shows driving circuits of the TFT substrate in this embodiment. In the circuit structure of FIG. **8**C, the power supply line and the cathode illustrated in FIG. **8**A are connected to the pixel unit in which each pixel is comprised of the organic light-emitting device of the present invention. A shift register is connected to the pixel unit via a latch **1** and a latch **2** in this order. A digital signal is inputted to the latch **1**, and a latch pulse is inputted to the latch **2** to transmit a picture data to the pixel unit.

A gate driver and a source driver are provided on the same substrate. In this embodiment, the pixel circuit and the drivers are designed to be digitally driven. Accordingly, fluctuation in TFT characteristics does not affect the device and the device can display uniform images.

Embodiment 5

The display devices of the present invention that have been demonstrated in the embodiments above have advantages of low power consumption and long lifetime. Accordingly, electric appliances that include those display devices as their display portions and the like can operate consuming less power than conventional ones and can be durable. The advantages are very useful especially for electric appliances that use batteries as power sources such as portable equipment, because low power consumption leads directly to conveniences (batteries last a long time).

The display device is self-luminous, whereby the backlight used in liquid crystal displays is not required. The device has an organic thin film whose thickness is less than 1 μm. Therefore the display device can be made thin and light-weight. Electric appliances that include the display device as their display portions ate accordingly thinner and lighter than conventional ones. This too leads directly to conveniences (lightless and compactness for carrying) and is very useful particularly for portable equipment and like other electric appliances. Moreover, being thin (unvolumninious) is doubtlessly useful for all of the electric appliances in terms of transportation (mass transportable) and installation (space-saving).

Being self luminous, the display device is characterized by having clear visibility in bright places and wide viewing angle than liquid crystal display devices. Therefore electric appliances that include the display device as their display portions have advantages of easiness in viewing display.

More specifically, electric appliances that use a display device of the present invention have, in addition to merits of conventional organic light-emitting devices, namely, thinness/lightness and high visibility, new features of low power consumption and long lifetime, and therefore are very useful.

This embodiment exemplified the electric appliances that include as display portions the display device of the present invention. Specific examples thereof are shown in FIGS. **9** and **10**. The organic light-emitting device included in the electric appliance of this embodiment can be any of the elements disclosed in the present invention. The light-emitting device included in the electric appliance of this embodiment can have any of the configurations illustrated in FIGS. **2**, **3**, and **5** to **8**.

FIG. **9**A shows a display using an organic light-emitting device. The display includes a case **901***a*, a support base **902***a*, and a display portion **903***a*. By using the light-emitting device of the present invention as the display portion **903***a*, the display can be thin and light-weight, as well as inexpensive. Accordingly, transportation is simplified, the desk space occupies as little as possible, and lifetime is long.

FIG. **9**B shows a video camera, which includes a main body **901***b*, a display portion **902***b*, a voice input portion **903***b*, operational switches **904***b*, a battery **905***b*, and an image receiving portion **906***b*. By using the light-emitting device of the present invention as the display portion **902***b*, the video camera consulates less power and can be light-weight. Therefore, the battery consumption decreases and carrying thereof also becomes easier.

FIG. **9**C shows a digital camera, which includes a main body **901***c*, a display portion **902***c*, a viewfinder **903***c*, and operational switches **904***c*. By using the light-emitting device of the present invention as the display portion **902***c*, the digital camera consumes less power and can be light-weight. Therefore, the battery consumption decreases and carrying thereof also becomes easier.

FIG. **9**D shows an image reproducing device equipped with a recording medium. The device includes of a main body **901***d*, a recording medium (such as CD, LD or DVD) **902***d*, operational switches **903***d*, a display portion A **904***d*, and a display portion B **905***d*. The display portion A **904***d* mainly displays image information whereas the display portion B **905***d* mainly displays text information. By using the light-emitting device of the present invention as the display portion A **904***d* and the display portion B **905***d*, the image reproducing device consumes less power and can be light-weight as well as inexpensive. This image reproducing device equipped with a recording medium may be a CD player, a game machine, or the like.

FIG. **9**E shows a mobile computer, which includes a main body **901***e*, a display portion **902***e*, an image receiving portion **903***e*, operational switches **904***e*, and a memory slot **905***e*. By using the light-emitting device of the present invention as the display portion **902***e*, the mobile computer consumes less power and can be thin and light weight. Therefore, the battery consumption decreases and carrying thereof also becomes easier. This mobile computer has a recording medium with a flash memory and a non-volatile memory integrated thereon, which can record and playback information.

FIG. **9**F shows a personal computer, which includes a main body **901***f*, a frame **902***f*, a display portion **903***f*, and a keyboard **904***f*. By using the light-emitting device of the present invention as tie display portion **903***f*, the personal computer consumes less power and can be thin and light-weight. When it is to be used as a mobile computer, that is, when there is a need to carry it, the low power consumption and the lightness will be of great advantage.

Note that the above electric appliances display information distributed through electronic communication lines such as the Internet or radio communication such as electric wave in many cases, and, in particular, display animated information with increasing frequency. Because organic light-emitting devices have very fast response speed, the above electric appliances are preferable for such animated display.

FIG. **10**A shows a mobile phone, which includes a main body **1001***a*, an audio output portion **1002***a*, an audio input portion **1003***a*, a display portion **1004***a*, operational switches **1005***a*, and an antenna **1006***a*. By using the light-emitting device of the present invention as the display portion **1004***a*, the mobile phone consumes less power and can be thin and light-weight. Therefore, the main body becomes compact, the battery consumption decreases, and carrying thereof also becomes easier.

FIG. **10**B is an audio playback device, (specifically a car audio system), which includes a main body **1001***b*, a display portion **1002***b*, and operational switches **1003***b*, and **1004***b*. By using the light-emitting device of the present invention as the display portion **1002***b*, the audio playback device consumes less power and can be light-weight. Although car audio is taken as an example in this embodiment, it may also be a home audio system.

In the electric appliances as shown in FIGS. **9** to **10**, it is effective to give a function for modulating the luminance of emitted light in accordance with brightness of the usage environment by further building-in an optical sensor and thus providing means for detecting brightness of the usage environment. If the user can ensure the brightness of 100 to 150 in contrast ratio in comparison with the brightness of the usage

environment, image or text information can be recognized without difficulty. Namely, when the environment is bright, the luminance of an image is raised so that the image can easily be viewed, while when the environment is dark, the luminance of the image is suppressed so as to lower the power consumption.

Embodiment 6

Conductive polymer may be formed in a stripe form by using a dispenser or ink jet scheme instead of applying it to the entire surface by the spin coating process. FIG. **11** shows a manner to form a conductive polymer **1106** to a pixel region **1102** of a substrate **1101** formed with a data drive circuit **1104**, by an ink jet scheme. The pixel region **1102** has banks **1105** in a stripe form to form the conductive polymer **1106** at between the banks. The banks **1105** are formed so that the adjacent ones of organic compound layers are not mixed with each other during forming organic compound layers by an ink jet scheme.

The conductive polymer **1106** is formed by ejecting a composition material containing conductive polymer through an ink head **1107**. The composition material is continuously ejected through the ink head to form a linear pattern.

FIG. **12**A shows a provision of insulating banks **103***a* in a form surrounding pixels **110***a* in order to form first electrodes **102***a* in a stripe form (vertical in the figure) and pixels **110***a* oil the substrate. FIG. **12**B shows a provision of insulating banks **103***b* in a form surrounding pixels **110***b* in order to form first electrodes **102***b* in an island form and pixels **110***b* on the substrate. In any case, the section taken along line A-A' in the figure is given as in FIG. **12**C. Namely, the conductive polymer **104** can be formed between the banks, in a separate form without formation on the banks **103**. On the conductive polymer layer, a light-emitting layer or electron injection/transport layer may be formed of a low-molecular compound material.

In such a case, the conductor polymer **104** has a thickness form of T**2**>T**1**>T**3** under the influence of the insulating bank **103**. Accordingly, the portion T**3** has an increased lateral resistance to prevent against crosstalk. Furthermore, because the portion T**2** has an increased thickness, the concentration of electric field can be relaxed at around the pixels to prevent the organic light-emitting element from deteriorating at around the pixels.

Embodiment 7

This embodiment shows an example to manufacture an active-matrix display device.

At first, on an insulating surface are formed a plurality of TFTs (including switching TFTs and current-control TFTs), holding capacitances, first electrodes (anodes) connected to current-control TFTs and banks coveting the ends of the first electrodes. The first electrode may be a material, an alloy or compound material which comprises at least an element selected from Ti, TiN, $TiSi_xN_y$, Ni, W, Wsi_x, WN_x, WSi_xN_y, NbN, Mo, Cr, Pt, or Ti, Si, Ni, W, Nb, Cr, Zn, Sn, In, Mo. In addition, the first electrode may use a film or a layered film based on these materials in a range of total film thickness of 100 nm to 800 nm. In order to provide preferred coverage, tie bank is made with a curved surface having a curvature at its upper or lower end thereof. For example, in the case the material of bank uses a positive photosensitive acryl, it is preferred to provide an insulator **1114** with a curved surface having a radius of curvature (0.2 μm-3 μm) at only an upper end thereof. For the bank, it is possible to use a negative type to be made insoluble in an enchant by photosensitive light or a positive type to be made soluble in an enchant by light.

Then, a hole injection layer is formed on a surface of the first electrode in a region not covered by the bank, by the application scheme. For example, a poly(ethylenedioxythiophene)/polystrene sulfonic acid solution (PEDOT/PSS) acting for a hole injection layer is applied to the entire surface by the spin coat scheme and then baked. After forming a hole injection layer by the application scheme, vacuum heating (at 100-200° C.) is preferably carried out immediately before film-forming due to a deposition process. For example, after washing the surface of the first electrode (anode) by a sponge, a poly(ethylenedioxythiophene)/polystrene sulfonic acid solution (PEDOT/PSS) is applied to the entire surface to a set film thickness of 60 nm by the spin coat scheme. This is pre-baked at 80° C. for 10 minutes and then baked at 200° C. for 1 hour. Furthermore, immediately before deposition, vacuum heating is carried out (heating at 170° C. for 30 minutes, cooling for 30 minutes) to form an organic thin film including a light-emitting layer without contact with the air by a deposition process. Particularly, in the case of using an ITO film as a first electrode material wherein concavo/convex or fine particles exist on the surface, the influence can be reduced by providing the PEDOT/PSS with a thickness of 30 nm or greater, with a result that point defects can be decreased.

Meanwhile, PEDOT/PSS if applied on an ITO film is not satisfactory in wettability. Accordingly, after a PEDOT/PSS solution is applied first by the spin coat process, it is once cleaned with pure water thereby improving wettability. Again, a PEDOT/PSS solution is applied second by the spin coat process and then baked, to preferably form a film with evenness. Incidentally, after the first application, once cleaning with pure water provides an effect to improve the quality of surface and remove fine particles.

In the case of forming a film of PEDOS/PSS by the spin coat process, the resulting film is over the entire surface. It is preferred to selectively remove it in regions of substrate end face and peripheral edge, terminals and connections between cathodes and lower interconnections Removal is preferably by O_2 ashing or the like.

Next, second electrodes (cathodes) are formed on the organic thin film. The second electrode may use a material having a small work function (Al, Ag, Li or Ca, or their alloy MgAg, MgIn, AlLi, CaF_2 or CaN). The second electrode is preferably evaporated by a resistance-heating process causing less damage to the TETs.

FIG. **13**A is a TEM photographic picture as observed by cutting a device of after forming the second electrodes. FIG. **13**B is a typical view corresponding to FIG. **3**A. In FIG. **13**A, PEDOT/PSS is formed approximately 90 nm on the first electrode.

This embodiment forms a curved surface having curvature at the upper or lower end of the bank. This provides a characteristic that, even by a spin coat process, the film thickness of the bank moderate sidewall is made smaller as distant from the first electrode, preferably the structure is made that a conductive polymer as a hole injection layer is absent on the upper part of the bank.

As shown in FIG. **13**A, PEDOT/PSS as a hole injection layer is not confirmed on the upper part of the bank despite it is present in a small thickness on the bank moderate sidewall. By providing the structure of FIG. **13**A, crosstalk can be effectively suppressed from occurring.

This embodiment can be freely combined with any one of the embodiment or Embodiments 1 to 6.

Embodiment 8

In the case that an organic light-emitting device of the invention is fabricated by using an apparatus as shown in FIG. **4**, during baking after applying an organic conductive material of conductive polymer or the like, baking is in a state the application surface is positioned down, i.e. face down. In this embodiment, experiment was conducted to confirm that a form as in Embodiment 7 is to be obtained by such a bake process.

First, PEDOT/PSS was applied to a substrate having an insulating bank having the same form as that of the structure of FIG. **13**, by the spin coat technique. Thereafter, bake was conducted at 200° C. with the application surface directed down. The form was observed by sectional TEM, the situation of which is shown in FIG. **15**. **1501** is an ITO and **1502** is a PEDOT/PSS layer. The layer **1503** somewhat white is a protection layer (carbon layer).

As shown in FIG. **15**, it was confirmed that the form quite similar to FIG. **13** can be obtained even when baking an organic conductive film after wet-application in a position of face down. Accordingly, the form as a feature of the invention can be formed regardless of a substrate position during baking.

Embodiment 9

This embodiment shows an example of a light-emitting device in a top emission structure. FIG. **16** shows a schematic view of the same.

FIG. **16**A is a top view showing a light-emitting device. FIG. **16**B is a sectional view taken on the line A-A' in FIG. **16**A. Reference numeral **1601** shown at the dotted line is a source-signal line drive circuit, reference numeral **1602** is a pixel region and reference numeral **1603** is a gate-signal line drive circuit. Reference numeral **1604** is a transparent seal substrate and reference numeral **1605** is a first seal material. A transparent second seal material **1607** is filled at the inside surrounded by the first seal material **1605**. The first seal material **1605** contains a gap material to sustain a gap between the substrates.

Reference numeral **1608** is an interconnection to convey a signal to be inputted to the source-signal line drive circuit **1601** and gate-signal line drive circuit **1603**. This receives a video or clock signal from an FPC (flexible print circuit) **1609** serving as an external input terminal. Note that, although only the FPC is shown herein, the FPC may be attached with a printed wiring board (PWB).

Next, explanation is made on a sectional structure by using FIG. **16**B. Although drive circuits and pixel region are formed on a substrate **1610**, a source-signal line drive circuit **1601** as a drive circuit and a pixel **1602** are shown herein.

The source-signal line drive circuit **1601** is formed by a CMOS circuit combined with an n-channel TFT **1623** and a p-channel TFT **1624**. The TFTs forming the drive circuit may be formed by a known CMOS circuit, PMOS circuit or NMOS circuit Although this embodiment shows a driver-integrated type forming drive circuits on the substrate, such configuration is not necessarily required, i.e. drive circuits can be externally formed instead of on the substrate.

The pixel region **1602** is formed with a plurality of pixels including a switching TFT **1611**, a current-control TFT **1612**, and a first electrode (anode) **1613** electrically connected to a drain of the same. The current-control TFT **1612** may be an n-channel TFT or p-channel TFT. However, this is preferably a p-channel TFT where connected to the anode. Meanwhile, it is preferred to properly provide a holding capacitance (not shown). It is noted that shown herein is an example on a sectional structure of one of the pixels arranged in a countless number wherein two TFTs are used on that one pixel. However, three or more TFTs may be properly used.

Because the first electrode **1613** herein is structurally, directly connected to a drain of the TFT, the layer under the first electrode **1613** is preferably formed of silicon material capable of having ohmic contact to the drain while the uppermost layer in contact with the layer containing an organic compound is of a material having a great work function. For example, in case providing a three-layer structure with a titanium nitride film, an aluminum-based film and a titanium nitride film, the interconnection has a low resistance to have a favorable ohmic contact and serve as an anode. Meanwhile, the first electrode **1613** may be made as a single layer of a titanium nitride film, a chromium film, a tungsten film, a Zn film or a Pt film, or may use three or more layers.

Insulating banks (also called banks or barrier walls) **1614** are formed at the both ends of the first electrode (anode) **1613**. The insulating banks **1614** may be formed of an insulator containing organic resin or silicon. Herein, as the insulating bank **1614**, an insulating bank in the form of FIG. **16** is formed by using a positive photosensitive acrylic resin.

In order to make coverage preferable and application of organic conductive material **930** even, a curved surface having curvature is formed at the tipper or lower end of the insulating bank **1614**. For example, in the case of using a positive photosensitive acryl as a material for the insulating bank **1614**, it is preferred to provide a curved surface with radius of curvature (0.2 μm-3 μm) only at the upper end of the insulating bank **1614**. The insulating bank **1614** can use a negative type to be made insoluble in an etchant by photosensitive light or a positive type to be made soluble in an etchant by light.

Meanwhile, the insulating bank **1614** may be covered by a protection film of an aluminum nitride film, an aluminum nitride oxide film, a carbon-based thin film or a silicon nitride film.

Herein, an organic conductor film **1630** is formed on the first electrode (anode) **1613** and insulating bank **1614**. Although this embodiment shows an example to apply conductive polymer by a spin coat process, another wet scheme may be used. Otherwise, it may be formed by a dry scheme to co-evaporate an organic material and acceptor or donor. It is noted that, in the case of carrying out spin-coat by using a water-solvent based one, such as PEDOT/PSS as conductive polymer, effectively applied is a method that hydrophilic treatment, such as UV ozone treatment or O_2 plasma treatment, is previously made on an application surface and thereafter spin coat is carried out.

In this embodiment, because the organic conductor film **1630** is formed by the spin coat process, it has been applied over the entire substrate surface immediately after the application. Accordingly, it is preferred to selectively remove it in regions of substrate end face and peripheral edge, terminals and connections between the second electrode **1616** and the interconnection **1608**. Removal is preferably by O_2 ashing or laser ablation.

On the organic conductor film **1630**, an organic thin film **1615** is selectively formed by a deposition process using a deposition mask or an ink jet scheme. Incidentally, the organic thin film **1615** in this embodiment is assumably a film to exhibit white light emission.

Furthermore, a second electrode (cathode) **1616** is formed on tie organic thin film **1615**. The cathode may use a material having small work function (Al, Ag, Li or Ca, or their alloy MgAg, MgIn, AlLi, CaF_2 or CaN). Herein, in order to trans-

mit emission light, the second electrode (cathode) **1616** uses layers of a metal thin film reduced in film thickness and a transparent conductive film (ITO (alloy of indium oxide and tin oxide), alloy of indium oxide and zinc oxide (In_2O_3—ZnO), zinc oxide (ZnO) or the like). In this manner, an organic light-emitting element **1618** is formed with the first electrode (anode) **1613**, the organic conductor film **1630**, the organic thin film **1615** and the second electrode (cathode) **1616**. Because the organic light-emitting element **1618** is made as an example to emit white light, full coloration is possible by providing a color filter having a coloring layer **1631** and shade layer (BM) **1632** (overcoat layer is not shown herein for simplification).

Meanwhile, in case selectively forming the layers respectively containing organic compounds to obtain R, C and B light emissions, fill-color display is available without using a color filter.

A transparent protection layer **1617** is formed to seal the organic light-emitting element **1618**. The transparent protection layer **1617** preferably uses an insulation film based on silicon nitride or silicon oxide nitride to be obtained by a sputter process (DC or RC scheme) or PCVD process, a thin film based on carbon (diamond-like carbon: DLC film, carbon nitride: CN film or the like) or a combined layers thereof In case a silicon target is used for formation in an atmosphere containing nitrogen and argon, it is possible to obtain a silicon nitride film having a high block effect against water content or impurities such as alkali metal. Otherwise, a silicon nitride target may be employed. The transparent protection layer may be formed by using a deposition apparatus using a remote plasma. In order to allow emission light to pass through the transparent protection layer, the film thickness of transparent protection layer is preferably made to a possible small extent.

In order to seal the organic light-emitting element **1618**, the seal substrate **1604** is bonded in an inert gas atmosphere by the use of a first seal material **1605** and second seal material **1607** The first seal material **1605** and second seal material **1607** preferably uses epoxy resin. The first seal material **1605** and second seal material **1607** is desirably of a material to pass possible less water content or oxygen.

This embodiment can use, as a material of the seal substrate **1604**, plastic of FRP (fiberglass-reinforced plastics), PVF (polyvinyl-fluoride), Mylar, polyester or acryl, besides glass or quartz. Meanwhile, after bonding the seal substrate **1604** by using the first seal material **1605** and second seal material **1607**, sealing can be made further with a third seal material in a manner covering a side surface (exposed surface).

As in the above, by sealing the organic light-emitting element in the first seal material **1605** and second seal material **1607**, the organic light-emitting element can be completely shielded from the outside. This makes it possible to prevent the intrusion from the external of the substance that accelerates deterioration of the organic compound layer, such as water content or oxygen. Thus, a reliable light-emitting device can be obtained.

Incidentally, in case the first electrode **1613** uses a transparent conductive film, it is possible to manufacture a light-emitting device of two-sided emission type.

By carrying out the invention described in the above, a conductive buffer layer using polymer can be applied to a display device having organic light-emitting elements matrix-arranged as pixels without causing crosstalk. Due to this, a display device can be provided which is low in drive voltage, excellent in reliability and heat resistance, and less in defects of short circuits or the like.

What is claimed is:

1. A display device including a plurality of pixels arranged in a matrix form, comprising:

a substrate;

at least a first insulating bank and a second insulating bank formed over the substrate;

a first electrode formed over the substrate and between the first insulating bank and the second insulating bank;

an organic conductive film comprising a low-molecular organic semiconductor and an accepter, wherein the organic conductive film is formed over the first electrode and on at least top surfaces of the first insulating bank and the second insulating bank;

an organic thin film containing an organic compound capable of causing electroluminescence formed over the organic conductive film and between the first insulating bank and the second insulating bank; and

a second electrode formed over the organic thin film,

wherein the top surfaces of the first insulating bank and the second insulating bank are not covered with the organic thin film containing the organic compound capable of causing electroluminescence,

wherein the organic conductive film formed in a vicinity of a top edge of the first insulating bank has a first thickness, and the organic conductive film formed in a vicinity of a center of the first electrode between the first insulating bank and the second insulating bank has a second thickness, and

wherein the second thickness is thicker than the first thickness.

2. The display device according to claim **1**, wherein the display device is an active matrix display device.

3. The display device according to claim **1**, wherein the display device is a passive matrix display device.

4. A display device including a plurality of pixels arranged in a matrix form, comprising:

a substrate;

at least a first insulating bank and a second insulating bank formed over the substrate;

a first electrode formed over the substrate and between the first insulating bank and the second insulating bank;

an organic conductive film comprising a low-molecular organic semiconductor and a donor, wherein the organic conductive film is formed over the first electrode and on at least top surfaces of the first insulating bank and the second insulating bank;

an organic thin film containing an organic compound capable of causing electroluminescence formed over the organic conductive film and between the first insulating bank and the second insulating bank; and

a second electrode formed over the organic thin film,

wherein the top surfaces of the first insulating bank and the second insulating bank are not covered with the organic thin film containing the organic compound capable of causing electroluminescence,

wherein the organic conductive film formed in a vicinity of a top edge of the first insulating bank has a first thickness, and the organic conductive film formed in a vicinity of a center of the first electrode between the first insulating bank and the second insulating bank has a second thickness, and

wherein the second thickness is thicker than the first thickness.

5. The display device according to claim **4**, wherein the display device is an active matrix display device.

6. The display device according to claim **4**, wherein the display device is a passive matrix display device.

7. A display device including a plurality of pixels arranged in a matrix form, comprising:
a substrate;
at least a first insulating bank and a second insulating bank formed over the substrate;
a first electrodes formed over the substrate and between the first insulating bank and the second insulating bank;
an organic conductive film covering surfaces of the first insulating bank and the second insulating bank and formed over the first electrode;
an organic thin film containing an organic compound capable of causing electroluminescence formed over the organic conductive film and between the first insulating bank and the second insulating banks; and
a second electrode formed over the organic thin film,
wherein the organic conductive film formed in a vicinity of a top edge of the first insulating bank has a first thickness, and the organic conductive film formed in a vicinity of a center of the first electrode between the first insulating bank and the second insulating bank has a second thickness, and
wherein the second thickness is thicker than the first thickness.

8. The display device according to claim 7, wherein the organic conductive film comprises a low-molecular organic semiconductor and an accepter.

9. The display device according to claim 7, wherein the organic conductive film comprises a low-molecular organic semiconductor and a donor.

10. The display device according to claim 7, wherein the display device is an active matrix display device.

11. The display device according to claim 7, wherein the display device is a passive matrix display device.

12. A display device including a plurality of pixels, each pixel comprising:
at least a first insulating bank and a second insulating bank formed over a substrate;
an electrode formed over a substrate and between the first insulating bank and a second insulating bank;
an organic conductive film formed over the electrode and on at least top surfaces of the first insulating bank and the second insulating bank;
an organic thin film containing an organic compound capable of causing electroluminescence formed over the organic conductive film and between the first insulating bank and the second insulating bank; and
a conductive layer formed over the organic thin film,
wherein the top surfaces of the first insulating bank and the second insulating bank are not covered with the organic thin film containing the organic compound capable of causing electroluminescence,
wherein the conductive layer extends over at least two pixels,
wherein the organic conductive film formed in a vicinity of a top edge of the first insulating bank has a first thickness, and the organic conductive film formed in a vicinity of a center of the first electrode between the first insulating bank and the second insulating bank has a second thickness, and
wherein the second thickness is thicker than the first thickness.

13. The display device according to claim 12, wherein the organic conductive film is a conductive polymer film.

14. The display device according to claim 12, wherein the organic conductive film is a polymer having π-conjugated system added with an acceptor or a donor.

15. A display device according to claim 12, wherein the organic conductive film has a conductivity of 10^{-6} S/cm or higher and 10^{-2} S/cm or lower.

16. The display device according to claim 12, wherein the organic conductive film comprises a low-molecular organic semiconductor and an accepter.

17. The display device according to claim 12, wherein the organic conductive film comprises a low-molecular organic semiconductor and a donor.

18. The display device according to claim 12, wherein the display device is an active matrix display device.

19. The display device according to claim 12, wherein the display device is a passive matrix display device.

20. A display device including a plurality of pixels arranged in a matrix form, comprising:
a substrate;
a first electrode formed over the substrate;
a second electrode formed over the substrate;
a first insulating bank formed over the substrate and a first edge portion of the first electrode;
a second insulating bank formed over the substrate, a second edge portion of the first electrode and a first edge portion of the second electrode;
a third insulating bank formed over the substrate and a second edge portion of the second electrode;
an organic conductive film formed over the first insulating bank, the second insulating bank, the third insulating bank, the first electrode and the second electrode;
a first organic thin film containing an organic compound capable of causing electroluminescence formed over the first electrode;
a second organic thin film containing an organic compound capable of causing electroluminescence formed over the second electrode,
wherein the second organic thin film is separated from the first organic thin film,
wherein the organic conductive film formed in a vicinity of a top edge of the first insulating bank has a first thickness, and the organic conductive film formed in a vicinity of a center of the first electrode between the first insulating bank and the second insulating bank has a second thickness, and
wherein the second thickness is thicker than the first thickness.

21. The display device according to claim 20, wherein the organic conductive film is a conductive polymer film.

22. The display device according to claim 20, wherein the organic conductive film is a polymer having π-conjugated system added with an acceptor or a donor.

23. A display device according to claim 20, wherein the organic conductive film has a conductivity of 10^{-6} S/cm or higher and 10^{-2} S/cm or lower.

24. The display device according to claim 20, wherein the organic conductive film comprises a low-molecular organic semiconductor and an accepter.

25. The display device according to claim 20, wherein the organic conductive film comprises a low-molecular organic semiconductor and a donor.

26. The display device according to claim 20, wherein the display device is an active matrix display device.

27. The display device according to claim 20, wherein the display device is a passive matrix display device.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,728,513 B2
APPLICATION NO. : 11/713910
DATED : June 1, 2010
INVENTOR(S) : Satoshi Seo et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page:

Item (57) In The Abstract:

Change "T2>T1>T3>" to -- T2>T1>T3 --.

In The Specification:

Column 1, Line 44, Change "emission," to -- emission. --.

Column 2, Line 15, Change "Chihaya" to -- Chihiaya --.

Column 2, Line 26, Change "light" to -- high --.

Column 2, Line 41, Change "(1997)," to -- (1997). --.

Column 2, Line 41, Change "ale" to -- al. --.

Column 2, Line 46, Change "Yoshilaru" to -- Yoshiharu --.

Column 2, Line 47, Change "vol," to -- vol. --.

Column 3, Line 19, Change "ROB" to -- RGB --.

Column 3, Line 57, Change "A, Elschner" to -- A. Elschner --.

Column 3, Line 58, Change "S, Kirchlmeyer" to -- S. Kirchmeyer --.

Column 3, Line 58, Change "K, Wussow" to -- K. Wussow --.

Column 4, Line 26, Change "electroluminescent" to -- electroluminescence --.

Column 5, Lines 7-8, Change "electroluminescent" to -- electroluminescence --.

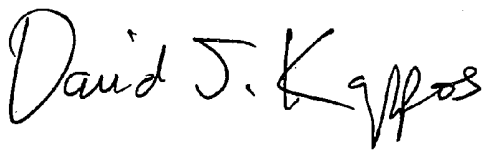
Column 6, Line 21, Change "like III" to -- like. In --.

Column 7, Line 29, Change "-(3-methulphlenyl)" to -- N-(3-methlphenyl) --.

Column 7, Line 35, Change "(4-biphenyril)" to -- (4-biphenylyl) --.

Signed and Sealed this

Thirtieth Day of November, 2010



David J. Kappos
Director of the United States Patent and Trademark Office

In The Specification:

Column 7, Line 36, Change "(p-tert-buthlylphenyl)" to -- (p-tert-buthylphenyl) --.

Column 7, Line 38, Change "(4-biphenyril)" to -- (4-biphenylyl) --.

Column 7, Lines 39-40, Change "(4-biphenyril)" to -- (4-biphenylyl) --.

Column 7, Line 43, Delete "•".

Column 7, Line 47, Change "tetrachiorodiphenoquinone" to -- tetrachlorodiphenoquinone --.

Column 8, Line 56, Change "refereed" to -- referred --.

Column 11, Line 36, Change "However;" to -- However, --.

Column 13, Line 53, Change "typically." to -- typically, --.

Column 13, Line 56, after "cover" Delete ",".

Column 14, Line 14, Change "embodiments" to -- embodiment --.

Column 14, Line 39, Change "Tr2," to -- Tr2. --.

Column 15, Line 24, Change "ate" to -- are --.

Column 15, Lines 25-26, Change "lightless" to -- lightness --.

Column 15, Line 28, Change "unvolumninious" to -- unvoluminous --.

Column 15, Line 63, Change "consulates" to -- consumes --.

Column 16, Line 32, Change "tie" to -- the --.

Column 17, Line 28, Change "oil" to -- on --.

Column 17, Line 54, Change "coveting" to -- covering --.

In Embodiment 7:

Column 17, Line 55, Change "may be a material" to -- may use, as a material --.

Column 17, Line 56, Change "which comprises at least an element" to -- of or based on an element --.

In The Specification:

Column 17, Line 61, Change "tie" to -- the --.

Column 18, Line 1, Change "enchant" to -- etchant --.

Column 18, Line 2, Change "enchant" to -- etchant --.

Column 18, Line 47, Change "TETs" to -- TFTs --.

Column 18 Line 50, Change "FIG. 3A" to -- FIG. 13A --.

Column 19, Line 57, after "circuit" insert -- . --.

Column 20, Line 26, Change "tipper" to -- upper --.

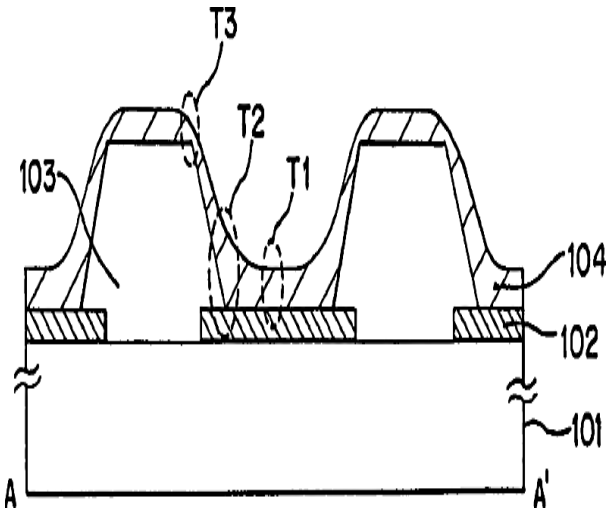
In The Specification:

Column 20, Line 65, Change “tie” to -- the --.

Column 21, Line 15, Change “R, C and B” to -- R, G and B --.

Column 21, Line 38, after “1607” insert -- . --.

专利名称(译)	显示装置及其制造方法		
公开(公告)号	US7728513	公开(公告)日	2010-06-01
申请号	US11/713910	申请日	2007-03-05
[标]申请(专利权)人(译)	株式会社半导体能源研究所		
申请(专利权)人(译)	半导体能源研究所有限公司.		
当前申请(专利权)人(译)	半导体能源研究所有限公司.		
[标]发明人	SEO SATOSHI YAMAZAKI SHUNPEI		
发明人	SEO, SATOSHI YAMAZAKI, SHUNPEI		
IPC分类号	H01L51/00 H01L27/32 H01L51/50		
CPC分类号	H01L27/3246 H01L51/5203 H05B33/10 H01L27/32 H01L51/5088 H01L27/3283 H01L51/5052 H01L27/3276 H01L51/5237 H01L51/56 H01L2251/558 H05B33/00		
优先权	2002016524 2002-01-25 JP 2002047379 2002-02-25 JP 2002255216 2002-08-30 JP 10/345745 2007-04-03 US		
其他公开文献	US20070200491A1		
外部链接	Espacenet USPTO		

摘要(译)

通过使用显示装置的制造提供消耗功率较低且寿命长的电气设备是一个问题。在基板上的第一电极上围绕像素部分的形式提供绝缘堤。通过湿法（方法），在绝缘堤的影响下，将有机导电膜施加到整个表面，该有机导电膜具有厚度形式T2> T1> T3>。因此，部分T3在横向方向上具有增加的电阻，使得可以防止串扰。由于导电聚合物作为缓冲层，可以提供驱动电压低的显示装置。此外，因为部分T2的厚度增加，所以在像素部分处和周围放松电场集中。这使得可以防止有机发光元件在像素周围劣化。