



(11) **EP 1 052 708 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
22.04.2009 Bulletin 2009/17

(51) Int Cl.:
H01L 27/32^(2006.01) H01L 51/52^(2006.01)

(21) Application number: **00110114.6**

(22) Date of filing: **10.05.2000**

(54) **Organic electroluminescence multicolor display and method of fabricating the same**

Organische elektrolumineszente vielfarben-Anzeigevorrichtung und Herstellungsverfahren

Dispositif d'affichage organique electroluminescent multicolore et procédé de fabrication

(84) Designated Contracting States:
DE GB

(30) Priority: **12.05.1999 JP 13150199**

(43) Date of publication of application:
15.11.2000 Bulletin 2000/46

(73) Proprietor: **Pioneer Corporation**
Meguro-ku,
Tokyo (JP)

(72) Inventor: **Fukuda, Yoshinori,**
Pioneer Corporation
Tsurugashima-shi,
Saitama 350-2288 (JP)

(74) Representative: **Klingseisen, Franz et al**
Klingseisen & Partner
Bräuhausstrasse 2
80331 München (DE)

(56) References cited:

EP-A- 0 616 488	EP-A- 0 773 707
JP-A- 10 319 870	US-A- 5 405 710
US-A- 5 742 129	US-A- 5 891 554

- **BURROWS P E ET AL: "CONTROL OF MICROCAVITY EFFECTS IN FULL COLOR STACKED ORGANIC LIGHT EMITTING DEVICES" APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 73, no. 4, 27 July 1998 (1998-07-27), pages 435-437, XP000774905 ISSN: 0003-6951**
- **TAKADA ET AL: "Controlled spontaneous emission in organic electroluminescent devices" OPTOELECTRONICS DEVICES AND TECHNOLOGIES, vol. 8, no. 3, September 1993 (1993-09), pages 403-412,**

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 1 052 708 B1

Description**BACKGROUND OF THE INVENTION**

1. Field of the Invention

[0001] The present invention relates to an organic electroluminescence multi-color display (also referred to as an organic EL multi-color display hereinafter) comprising a plurality of organic electroluminescent elements (hereinafter also referred to as organic EL elements) using an electroluminescent organic compound emitting light by injection of an electric current and provided with an emission layer made from such an organic electroluminescent material and moreover to a process for fabricating the organic EL multi-color display.

2. Description of the Related Art

[0002] The organic EL element using the organic compound material is typically a light emitting element having diode characteristic of an electric current injection type which emits light at the intensity corresponding to the amount of current. A display panel having a plurality of such EL elements arranged in a matrix has been developed. The display panel includes a substrate structure as shown in Fig. 1 which is fabricated in the following manner. An indium-tin-oxide (so-called ITO) film is deposited on a glass substrate 2 serving as a display screen, and the obtained ITO film is patterned by means of etching, thereby an anode 3 is formed on the substrate as a transparent electrode. Each organic EL device 1 constituting the display panel has a multi-layer structure wherein a plurality of organic compound material layers 4 including a light emitting layer and a cathode 5 (a metal electrode) have been deposited in this order on the anode 3 (a transparent electrode) by vacuum vapor deposition or the like. When required, the organic compound material layer 4 is provided with a hole transport function layer (a hole injection layer, a hole transport layer) and an electron-transport-function layer (an electron injection layer, an electron-transport layer) in addition to the light-emitting layer.

[0003] For example, Japanese Patent No. 2846571 discloses an organic EL element in which the thickness of the ITO anode and a plurality of organic compound material layers are so set that the desired wavelength of the light obtained from the light emitting layer can have a peak wavelength.

[0004] In the conventional organic EL element, the thicknesses of the ITO anode and a plurality of organic compound material layers are set in such a manner that the spectrum of the light obtained from the light emitting layer can have a desired peak wavelength. If such conventional organic EL element is adapted to an organic EL multi-color display, then a change of the thickness of the ITO anode is required so as to depend on the pixel for emitting light of a different color, that is, on each of the organic EL elements.

[0005] Since the ITO anode is deposited uniformly on the entire surface of a transparent substrate and thereafter formed into the desired thickness and pattern by etching, it is difficult to vary the thickness of the ITO anode partly for many elements on the same display substrate. In addition, this uneven ITO anode would make the manufacture of the display panel complicated since the ITO needs to repeat a deposition process partly in order to vary the thickness of the ITO anode in part.

[0006] Further, US-A-5,742,129 discloses an organic electroluminescence monochrome display device forming the basis for the preamble of appending claims 1 and 11.

OBJECT AND SUMMARY OF THE INVENTION

[0007] An object of the present invention is to provide an organic EL multi-color display and a method for fabricating the organic EL multi-color display, which can be fabricated easily and provides an excellent external quantum efficiency of light.

[0008] This object is achieved by an organic EL multi-color display device comprising the features of appending claim 1 as well as by a method for fabricating an organic EL multi-color display device comprising the features of appending claim 10. Further developments and preferred modes for carrying out the invention are defined in respective subclaims.

[0009] According to the present invention, the organic compound material layers are formed in two or more processes for depositing such as the common layer and the complementary layer to adjust the thickness of the complementary layer of the organic compound material layers. Such organic EL elements can thereby be obtained that can provide improved light emission efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig. 1 is a schematic cross-sectional view showing an organic EL element;

Fig. 2 is a schematic partially cross-sectional view showing an organic EL multi-color display according to an embodiment of the present invention;

Figs. 3 through 7 are schematic partially cross-sectional views each showing an organic EL multi-color display according to other embodiments of the present invention; respectively.

Figs. 8 through 13 are schematic partially cross-sectional views each showing a substrate in the process by a method for fabricating an organic EL multi-color display according to the embodiments of the present invention, respectively;

Fig. 14 is a sectional view showing the organic EL element of the present invention;

Fig. 15 is a sectional view showing the reflection at a transparent electrode side portion in the organic EL element of the present invention;

Fig. 16 is a sectional view showing the reflection at a metal electrode side portion in the organic EL element of the present invention;

Fig. 17 is a cross-sectional view of an organic EL element fabricated for a test;

Fig. 18 is a graph showing the characteristics of the external quantum efficiency in relation to the thickness of a hole transport layer of an organic EL element according to the present invention;

Fig. 19 is a graph showing the spectrum of an organic EL element according to the present invention; and

Figs. 20 and 21 are schematic partially cross-sectional views each showing a fabricated example of an organic EL multi-color display panel according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] Embodiments of an organic EL element and the method for fabricating the element, according to the present invention, are explained with reference to the drawings.

[0012] In a first embodiment, an organic EL multi-color display is explained in which the hole transport layer is formed from a common organic compound material as the organic compound material layers irrespective of colors of emitted light of the EL element.

[0013] The organic EL multi-color display shown in Fig. 2 comprises a plurality of organic EL elements. Each of the organic EL elements comprises a transparent electrode 3 as the anode made of ITO or the like, a hole transport layer comprising a hole transport layer common layer 42a and hole transport layer complementary layers 42G, 42R, each of which is made of organic compound materials, light emitting layers 43B, 43G, 43R, made of organic compound materials, and a metal electrode 5 as the cathode, each of which is stacked in sequence on a transparent substrate 2 such as made of glass. In addition, there is provided a sealing film (not shown) made of SiN_4 on the metal electrode 5, thereby isolating each of the organic EL elements from the atmosphere.

[0014] The light emitting layers 43B, 43G, 43R, which are stacked independently and individually, comprise different organic compound materials that show different colors of emitted light of blue, green, and red on application of current, respectively. As such, the organic EL multi-color display has, as a pixel, a group of the organic EL elements with colors of emitted light of blue, green, and red, and for example has a plurality of these pixels arranged in a matrix.

[0015] The hole transport layer common layer 42a is a common layer made of the same material as used for that of all adjacent organic EL elements and having a constant continuous thickness. The hole transport layer complementary layers 42G, 42R are made of the same organic compound material as that of the hole transport layer common layer 42a. The hole transport layer complementary layers 42G, 42R are stacked on the common layer 42a independently and individually with each having a different thickness of film corresponding to each color of emitted light of green and red. The thickness of film of the hole transport layer common layer 42a is set to the thinnest thickness corresponding to the emitted light color of blue of the light emitting layer 43B.

[0016] By the combination of a complementary layer and the common layer, each hole transport layer is to have a different thickness of film corresponding to each color of emitted light (wavelength λ). That is, in the organic EL elements, any one of the functional layers of the organic compound material layers, excluding the light emitting layers and having the same function, has a different thickness of film corresponding to the color of emitted light. Therefore, the setting of the thickness of the film of the hole transport layer, the common layer 42a, and the hole transport layer complementary layers 42G, 42R enables defining the optimum position of the light emitting layers for obtaining each of the colors of emitted light. Accordingly, this enables forming the transparent electrode 3 of all organic EL elements in a constant thickness without the necessity to change the thickness thereof.

[0017] Furthermore, in the aforementioned embodiment, the hole transport layer complementary layers 42G, 42R are formed from the same organic compound material as that used for the hole transport layer common layer 42a. However, as a second embodiment, the hole transport layer complementary layers 42G, 42R may be made of materials different from that of the hole transport layer common layer 42a, respectively. That is, different hole transport organic compound materials may be used to form each of the light emitting layers 43B, 43G, 43R of three colors of emitted light.

[0018] As a third embodiment shown in Fig. 3, such an organic EL multi-color display may be employed that has a

hole injection layer 41 stacked in between the hole transport layer common layer 42a and the ITO anode 3 and otherwise has the same configuration as the aforementioned embodiment.

[0019] In addition, as a fourth embodiment shown in Fig. 4, such an organic EL multi-color display may be employed that has the hole injection layer 41 stacked on the transparent electrode 3 as a common layer, on which the hole transport layer complementary layers 42B, 42G, 42R, each having a different thickness and made of the same organic compound material, are stacked, and has otherwise the same configuration as the aforementioned embodiment. Moreover, such an organic EL multi-color display may be employed that has the hole transport layer complementary layers 42B, 42G, 42R, having a different thickness and made of different materials, stacked on the common layer of the hole injection layer 41 and otherwise has the same configuration as the aforementioned embodiment.

[0020] Furthermore, as a fifth embodiment shown in Fig. 5, such an organic EL multi-color display may be employed that has each of electron transport layers 44B, 44G, 44R, stacked in between each of the light emitting layers 43B, 43G, 43R and the metal electrode 5, and otherwise includes the same organic EL elements with a three layer configuration as the aforementioned embodiment. In a modified example of the fifth embodiment, such an organic EL multi-color display may be employed that has an electron injection layer is stacked in between the electron transport layers 44B, 44G, 44R and the metal electrode 5, and otherwise is the same as the aforementioned embodiment.

[0021] Moreover, the aforementioned embodiment employs the transparent electrode 3 comprising ITO or the like as the anode and the metal electrode 5 as the cathode. However, in a sixth embodiment, as shown in Fig. 6, such a configuration can be employed that the transparent electrode 3 comprising ITO or the like is used as the cathode and the metal electrode 5 as the anode, with a functional layer stacked in between the electrodes. That is, such an organic EL multi-color display may be employed in which an electron transport layer common layer 44a made of an organic compound material is stacked on the transparent electrode 3 on the transparent substrate 2, while an electron transport layer comprising electron transport layer complementary layers 44G, 44R made of an organic compound material, the light emitting layers 43B, 43G, 43R made of an organic compound material, and the hole transport layers 42B, 42G, 42R corresponding to the materials of the light emitting layers are stacked in sequence in the respective predetermined positions.

[0022] Furthermore, as a seventh embodiment shown in Fig. 7, such an organic EL multi-color display may be employed that has an electron injection layer 45 is stacked in between the electron transport layer common layer 44a and the ITO cathode 3, and is otherwise the same as the aforementioned sixth embodiment. In the modified example according to the seventh embodiment, the electron injection layers 45 may be formed from the same material and independently as well as may be formed as a common layer. Furthermore, in the aforementioned sixth and seventh embodiments, a hole transport layer is stacked in between each of the light emitting layers 43B, 43G, 43R and the metal electrode 5, however, such an organic EL multi-color display may be employed that excludes the hole transport layer but includes an organic EL element having a two-layer configuration.

[0023] Still furthermore, in addition to the first embodiment of Fig. 2 showing the element of the two-layer configuration made of an organic compound material, Fig. 20 shows an eighth embodiment. The organic EL multi-color display having a three-layer configuration may be employed in which the electron transport layer complementary layers 44B, 44G are stacked on the two-layer configuration made of an organic compound material of Fig. 2, that is, on the light emitting layers 43B, 43G made of an organic compound material, respectively, and further the electron transport layer common layer 44a made of an organic compound material is stacked thereon.

[0024] Next, the fabricating process of a display panel of the organic EL multi-color display is explained.

[0025] First, as shown in Fig. 8, the B, G, and R transparent electrodes (anodes) 3 made of ITO are extended in parallel to and formed on the glass substrate 2, respectively. After an ITO transparent layer is deposited by sputtering or the like, the ITO transparent layer is patterned into the electrodes 3 with a constant thickness by means of etching or the like. The drawing shows lines defining the ITO layers, and a metal having a low resistivity such as Al may be further stacked on the ITO layers. Moreover, on the substrate 2 comprising each of the conductive portions of the ITO, an insulating layer such as made of polyimide may be deposited which has an opening for exposing the transparent electrode 3 in order to allow a light emitting layer including a light emitting organic electroluminescence material to be stacked. Moreover, a plurality of ribs, made of photosensitive polyimide, for patterning cathode lines may be provided in parallel to each other, orthogonal to the transparent electrode lines 3.

[0026] Next, as shown in Fig. 9, the hole transport layer common layer 42a is deposited entirely to cover the glass substrate 2 and the transparent electrode 3 by means of the vacuum vapor deposition or the like. In addition, prior to the deposition of the hole transport layer common layer 42a, a process may be added in which the hole injection layer is deposited on the transparent electrode 3 to dispose the hole injection layer in between the hole transport layer and the anode.

[0027] Next, as shown in Fig. 10, on the upper portion corresponding to the predetermined transparent electrode 3 on the hole transport layer common layer 42a, a blue light emitting organic EL medium of B, G, and R is deposited in a predetermined thickness to form the light emitting layer 43B, using a predetermined light emitting layer deposition mask.

[0028] Next, as shown in Fig. 11, the opening of the light emitting layer deposition mask is moved to the upper portion

corresponding to the subsequent transparent electrode 3 on the hole transport layer common layer 42a. Then, the hole transport layer complementary layer 42G suitable as a green light emitting organic EL medium of B, G, and R is deposited, and further thereon, the green light emitting organic EL medium is deposited in a predetermined thickness to form the light emitting layer 43G.

[0029] Likewise, as shown in Fig. 12, the opening of the light emitting layer deposition mask is moved to the upper portion corresponding to the subsequent transparent electrode 3 on the hole transport layer common layer 42a. Then, the hole transport layer complementary layer 42R suitable as a red light emitting organic EL medium of B, G, and R is deposited, and further thereon, the red light emitting organic EL medium is deposited in a predetermined thickness to form the light emitting layer 43R. Here, the hole transport layer complementary layers 42G, 42R are to be deposited using organic compound materials different from each other, however, these complementary layers can be deposited using the same organic compound material as the hole transport layer common layer.

[0030] Next, as shown in Fig. 13, the deposition mask is removed and a metal having a low work function such as Al-Li is deposited on the light emitting layers 43B, 43G, 43R of the three types of deposited organic EL media by means of vapor deposition, sputtering or the like into the cathode metal electrode 5. The metallic film may be deposited as thick as possible unless the thickness thereof would not cause trouble. The processes described above make it possible to fabricate the display panel of the organic EL multi-color display according to the embodiment.

[0031] In the processes of the embodiments shown in Fig. 8 through Fig. 13, such an explanation is given that the organic compound material layer sandwiched by both electrodes has the two-layer configuration in which the hole transport layer common layer, the complementary layer, and the light emitting layer are stacked in that order. However, in the case where the hole transport layer complementary layer is deposited using the same organic compound material as that of the hole transport layer common layer, such a two-layer configuration may be employed in which the hole transport layer complementary layer, the common layer, and the light emitting layer are stacked in that order. That is, before or after the common layer stacking process for stacking the common layer, the complementary layer in contact with the common layer may be stacked in a different thickness corresponding to each of the colors of emitted light.

[0032] The present invention can employ not only the aforementioned organic EL elements of the two-layer configuration but also a three-layer configuration in which the electron transport layer is stacked further on the light emitting layer. In this case, a process (Fig. 13) for depositing the electron transport layer on the light emitting layers 43B, 43G, 43R is added to between the process (Fig. 12) for depositing the light emitting layer and the process (Fig. 13) for depositing the cathode metal electrode on the light emitting layer, both of which are according to the embodiments shown in Fig. 8 through Fig. 13. Furthermore, the electron injection layer may be disposed in between the electron transport layer and the cathode by adding a process for depositing the electron injection layer on the electron transport layer after the electron transport layer has been stacked.

[0033] As such, according to the present invention, at least one organic compound material layer of the hole transport functional layer (hole injection layer, hole transport layer) on the anode side and the electron transport functional layer (the electron injection layer, the electron transport layer) on the cathode side, both of which sandwich the light emitting layer is deposited in two or more processes for the common layer and the complementary layer in order to adjust the thickness of the complementary layer of an organic compound material layer. This makes it possible to improve the external light emission efficiency, however, the setting of the thickness of the common layer and the complementary layer requires the setting the thickness of the organic compound material layer of the following settings (a) on the cathode side and (b) on the anode side.

(a) Setting the optical film thickness on the cathode side (the light emitting layer, the electron transport layer)

[0034] First, on the precondition that the ITO and the hole transport layer have a constant thickness, the thickness of the organic compound material layer on the cathode side is adjusted to obtain the desired light emission spectrum. This is done to minimize the attenuation cause by interference since a largest amount of reflected light from the cathode side is found at the light emission boundary. In the case where the light emitting layer has a guest/host configuration, the dope of the guest material (the portion that emits light) is adjusted to the desired value. Normally, in order to maximize the intensity of light emission, the primary reflected light at the cathode is made in phase with the emitted light at the light emission boundaries (at the position where the emitted light takes on a peak intensity within the light emitting layer).

(b) Setting the optical film thickness on the anode side (hole transport layer)

[0035] Adjustment of the thickness of the hole transport layer would vary the spectrum of the emitted light. Hereupon, with the thickness of the film on the cathode side being fixed to the setting, the thickness of the hole transport layer is set so that light is emitted to the desired amount. At this time, the thickness of ITO is made constant. The characteristics may be determined so that the desired wavelength takes on a peak value in the case of the organic EL multi-color display, whereas the organic EL full-color display requires well-balanced setting in consideration of harmony of the three

colors.

[0036] Making the hole transport layer thicker would cause the current to luminance intensity (I-L) characteristic not to be varied, however, the voltage to luminance intensity (V-L) characteristic to deteriorate. By making use of this nature, it is possible to make the drive condition the same for each of the colors. The settings (a) and (b) of optical film thickness described above, are carried out in that order on each of the R, G, and B organic EL elements.

[0037] Next, there are explained the optical film thickness and method for emitting light predominantly composed of the desired wavelength λ from each of the organic EL elements.

[0038] It has been known that the distribution of light emission intensity within the light emitting layer of the organic EL element is strong on the boundary surface, wherein the hole transport layer and the like are placed, close to the transparent electrode, and decreases with decreasing distance to the metal electrode, on which the electron transport layer and the like are placed. That is, it is known that the distribution is an exponential distribution with respect to the film thickness of the light emitting layer, and that the interface close to the transparent electrode is the light emitting interface having the peak in light emission intensity.

[0039] As shown in Fig. 14, in the organic EL element 1 having a structure wherein the ITO transparent electrode 3, a plurality of organic compound material layers 4 including the light emitting layer, and the metal electrode 5 are deposited in this order on the glass substrate 2, the organic compound material layers are partitioned with the light emitting interface 10 of the light emitting layer into the transparent electrode side portion 4d and the metal electrode side portion 4D.

[0040] In the organic EL element 1, the interface between the metal electrode 5 and the organic compound material layer 4D can be regarded as a total-reflecting interface. Accordingly, light traveling from the light emitting interface 10 of the light emitting layer to the metal electrode is totally reflected and goes through the light emitting interface 10, thereby to contribute to external light emission. As a matter of course, most of the light traveling to the transparent electrode 3 contributes to external light emission.

[0041] On the other hand, because the refractive index difference between the glass substrate 2 and the transparent electrode 3 is much larger than the differences between other adjacent layers, the interface having the largest refractive index difference in the transparent electrode side portion acts markedly as a reflecting interface. The refractive indices of materials used for fabrication of the organic EL element are as follows: the organic compound material layers 4d and 4D are about 1.8; the ITO transparent electrode 3 is about 2.0; and the glass (soda-lime glass) substrate 2 is about 1.5. Therefore, the difference of refractive index is 0.2 between the organic compound material layer 4d and the ITO transparent electrode 3, and the difference of 0.5 between the glass substrate 2 and the transparent electrode 3. The difference of refractive index between the glass substrate 2 and the transparent electrode 3 is largest in the transparent electrode side portion. In the case of the light traveling from the light emitting interface 10 of the light emitting layer to the transparent electrode 3 and coming back to the light emitting interface 10, the small difference between the organic compound material layer 4d and the transparent electrode 3 is neglected, and the largest refractive index difference between the glass substrate 2 and the transparent electrode 3 is taken into account. The largest refractive index difference can be provided not only between the glass substrate and the transparent electrode, but also within the organic compound material layer 4d, through use of materials having high refractive index deposited therein.

[0042] In the organic EL element as shown in Fig. 14, the main light-traveling routes of the light emitted on the light emitting interface are as follows: the route (1) the light goes from the light emitting interface directly to the outside; the route ((2) the light is reflected on the metal electrode, comes back to the light emitting interface, and then goes outside directly; and the route (3) the light is reflected on the glass, comes back to the light emitting interface, and goes outside. The final chromaticity and light emission efficiency are dependent on the course of light interference in the cases of routes (2) and (3) wherein light comes back to the light emitting interface, though the intensity of light back through the route (2) in the light emitting interface is larger than that of the route (3).

[0043] First, in the case of setting the optical film thickness at the anode side with the order of (b) above mentioned, the interference in the light-traveling route (3) of the transparent electrode side portion 4d of the organic compound material layer will be considered. As shown in Fig. 14, when the refractive index is "n" and the film thickness is "d", as a whole, of the light which is reflected on the interface between the transparent electrode 3 and the glass substrate 2 and comes back to the light emitting interface, its length of optical path (2 nd) is the sum of the length of the optical paths in the organic compound material layer and the transparent electrode, and can be expressed by the following formula:

$$2 \text{ nd} = 2 (n_{\text{org}} d_{\text{org}} + n_{\text{ITO}} d_{\text{ITO}})$$

wherein n_{org} is the refractive index of the organic compound material layer 4d; d_{org} is the film thickness of the organic compound material layer 4d; n_{ITO} is the refractive index of the transparent electrode 3; and d_{ITO} is the film thickness of the transparent electrode 3. Accordingly, when the length of the optical path of the going and returning light "2nd" is equal to integer multiple of the wavelength λ which is emitted and is to be taken out, the interference between the

returning light and the emitted light becomes maximum. As shown in Fig. 15, therefore, the optical distance, from the light emitting interface to the interface of the largest refractive index difference, which is used for establishment of the film thickness of the organic compound material layer 4d giving the maximum interference effect, can be expressed by the following formula:

$$2 (n_{\text{org}}d_{\text{org}} + n_{\text{ITO}}d_{\text{ITO}}) = j \cdot \lambda$$

$$\therefore (n_{\text{org}}d_{\text{org}} + n_{\text{ITO}}d_{\text{ITO}}) = 2j \cdot (\lambda / 4)$$

wherein "j" represents an integer of 1 or more.

When the total film thickness of the organic compound material layer 4d and the transparent electrode 3 is established to be approximately the length of the optical distance, the interference enhances the light emission efficiency. More specifically, for purpose of setting the total thickness of the organic compound material layers 4d, i.e., common layer and complementary layers to obtain the maximum interference effect, the transparent electrode side portion of those organic compound material layers are deposited to have a film thickness such that the optical distance ($n_{\text{org}}d_{\text{org}} + n_{\text{ITO}}d_{\text{ITO}}$) from the light emitting interface 10 to the interface of the largest refractive index difference is approximately equal to even multiples of one quarter of the wavelength of λ .

[0044] Moreover, in the case of the setting (a) for the optical film thickness on the cathode side, the interference in the light-traveling route (2) of the metal electrode side portion 4D of the organic compound material layer will be considered.

As shown in Fig. 14, since the reflection occurs on the interface between the metal electrode 5 and the metal electrode side portion 4D of the organic compound material layer, a phase difference π occurs before and after the reflection of light. Accordingly, when the refractive index is "n" and the film thickness is "D", as a whole, of the metal electrode side portion 4D of the organic compound material layer of the light returning to the light emitting interface, the length of the optical path can be expressed by "2 nD". As shown in Fig. 16, when the length of the optical path (2 nD) of the going and returning light is equal to the wavelength ($\lambda/2, 3\lambda/2, 5\lambda/2, \dots$) of the light emitted and is to be taken out, the interference of the returning light and the emitted light becomes maximum. The film thickness of the organic compound material layer 4D (a total thickness of the common layer and complementary layers) wherein the maximum interference effect is obtained, that is, the optical distance from the light emitting interface 10 to the metal electrode 5 can be expressed by the following formula:

$$2 nD = [(2j - 1)/2] \lambda$$

$$\therefore nD = [(2j - 1)/4] \lambda$$

wherein "j" represents an integer of 1 or more.

When the film thickness "D" of the organic compound material layer 4D is established to be approximately the length of the optical distance, the interference enhances the light emission efficiency. More specifically, the film thickness "D" of the metal electrode side portion of the organic compound material layer is deposited to have a film thickness such that the optimal distance "nD" from the light emitting interface 10 to the interface bordering on the metal electrode 5 is approximately equal to odd multiples of one quarter of the wavelength of λ .

[0045] In the case of fabrication of organic EL elements, as the first forming step of the organic compound material layer, the transparent electrode side portion of the organic compound material layer is formed on the transparent electrode formed on the light-transmitting substrate by depositing one or more of the organic compound material layers, other than the light emitting layer emitting a light having a wavelength of λ and serving as a primary component, which have a film thickness such that the optical distance from the light emitting interface of the light emitting layer to the interface having the largest refractive index difference is approximately equal to even multiples of one quarter of the wavelength of λ . Subsequently, as the second forming step of the organic compound material layer, the metal electrode side portion of the organic compound material layer is formed on the transparent electrode side portion of the organic compound material layer by depositing the light emitting layer and the remaining portion the organic compound material layer such that the

light emitting layer and the remaining portion have a film thickness wherein the optical distance from the light emitting interface of the light emitting layer to the interface on the metal electrode is approximately equal to odd multiples of one quarter of the wavelength of λ , and then the metal electrode is formed on the metal electrode side portion of the organic compound material layer.

[0046] Since the element has the foregoing structure, as the film thickness of the organic compound material layer is gradually increased, the film thickness wherein the phases in the above described light-traveling routes agree with each other appears one after another. In particular, as the film thickness is increased, the element demonstrates the maximum and minimum values in the light emission efficiency characteristics with respect to the film thickness of the transparent electrode side portion of the organic compound material layer. In other words, the light emission efficiency characteristics depend on the total film thickness of the organic compound material layers of the transparent electrode side.

[0047] For example, as shown in Fig. 14, a plurality of organic EL elements were fabricated in which the transparent electrode (anode) 3, the hole transport layer 42, the light emitting layer 43, and the metal electrode (cathode) 5 are deposited in that order on the substrate 2, in which those layer are made of a material (in a thickness) of ITO (100 nm or 175 nm), TPD (40 - 200 nm), aluminum oxine chelate Alq3 (60 nm), and aluminum lithium alloy Al-Li respectively. Each of the elements having hole transport layers different in thickness as such was subjected to the measurement of the external quantum efficiency of the organic EL element and the EL spectrum.

[0048] Fig. 18 shows the relationship between the thickness of the hole transport layer that is a part of the organic compound material layer and the external quantum efficiency of the organic EL element. The plot with the horizontal axis representing the thickness of the hole transport layer and the vertical axis representing the external quantum efficiency shows that the efficiency increases and decreases periodically as shown in Fig. 18 with respect to a transparent electrode of the same thickness (100 nm or 175 nm). In Fig. 18, two types of transparent electrodes 100 nm and 175 nm in thickness are plotted with the curves of a dotted line and a solid line, respectively. As for the relationship between both curves, the curves have the same period of an increase and decrease but are about half the period out of phase with each other. This is because the difference in thickness (75 nm) between the two types of transparent electrodes is optically an odd multiple of half the wavelength of the peak wavelength (520 nm) of the EL spectrum, so that the strengths of interference are 180° out of phase with each other. Moreover, when the stepped difference in refractive index between the transparent electrode and the organic compound material layer is large, the difference in amplitude between both curves is considered caused by the effect of the reflection from this boundary surface.

[0049] Varied is not only the intensity efficiency of the EL but also the light emission spectrum. Fig. 19 shows three types of EL spectra of organic EL elements fabricated. The solid line represents the spectrum of the organic EL element 175 nm in the thickness of the transparent electrode, while the dashed line represents the spectrum of the organic EL element 100 nm in the thickness of the transparent electrode. The curves are so normalized that the maximum peak of the spectrum takes on 1.0. Excluding the film thickness of the transparent electrodes, the both are completely the same to each other, however, it can be found that the spectrum of the organic EL element 100 nm in the thickness of the transparent electrode is broader than that of the organic EL element 175 nm in the thickness of the transparent electrode and the color varies in accordance with the film thickness of the transparent electrode.

[0050] The curve shown by a dotted line in Fig. 19 was obtained by adjusting the film thickness of the hole transport layer to make the optical distance between the light emitting surface and the boundary surface between the glass and transparent electrode the same as that of the element represented by the solid line. Specifically, the difference of 75 nm in film thickness between the transparent electrodes was compensated by making the hole transport layer thicker by 80 nm. The dotted line and the solid line show substantially the same spectrum and the elements were made possible to be fabricated without varying the colors thereof.

[0051] The correction of the film thickness of the transparent electrode by varying the thickness of the hole transport layer allows the optical configuration to be assumed the same, so that the efficiency of light emission can be made equal. However, when the reflection on the boundary surface of the transparent electrode and the hole transport layer exerts an effect, the peak value of the maximum efficiency possibly varies depending on the thickness of the ITO transparent electrode in some cases.

[0052] As can be seen from the results described above, the distance between the substrate and the boundary surface of light emission can be varied without changing the efficiency and colors by optimizing the optical film thickness of the hole transport layer with the transparent electrode being kept constant in film thickness.

[0053] Furthermore, when a multi-color light emitting portion is fabricated on the same substrate, the optimum distance between the substrate and the boundary surface of light emission is different depending on the color of light emission. However, by adjusting the film thickness of the hole transport layer of each color so as to obtain the optimum optical distance, a multi-color light emitting portion that has the optimum current efficiency and color can be fabricated on the transparent electrode of the same thickness.

[0054] As specifically shown in Fig. 21, a panel having a transparent glass substrate was fabricated which is sealed with a SiN₄ sealing film layer and comprises organic EL elements having a two-layer and three-layer configuration.

[0055] First, the thickness of the optical film on the cathode side of the aforementioned (a) was designed in accordance

with the thickness of the optical film for emitting light predominantly composed of the desired wavelength λ of each organic EL element and the setting method. On the precondition that the ITO and the hole transport layer have a film of a constant thickness, the design was carried out by adjusting the film thickness of the light emitting layer on the cathode side and the electron transport layer so as to be able to obtain the desired light emission spectrum. Here, the light emitting layer has a guest / host configuration, the dope of the guest material was adjusted to the desired value. The values assumed and the results are shown in Table 1.

Table 1

	Transparent electrode [Material/ thickness (nm)]	Hole transport layer [Material/ thickness(nm)]	Light emitting layer [Material/ thickness(nm)]	Electron transport layer [Material/ thickness(nm)]
B	ITO/ 100	TPD/70	PC-7 ** /30	Alq/20
G	ITO/ 100	TPD/70	Alq/60	
R	ITO/ 100	TPD/70	Alq : DCM*/40 I	Alq/30

* 0.8% by volume of DCM was doped into Alq. DCM stands for 4 - (dicyano methylene) - 2 - methyl - 6 (p - dimethyl aminostyryl) - 4H - pyran.
 ** PC-7 stands for bis (2 - methyl - 8 - quenolilate) (para - phenyl-phenolate) aluminum (III).

[0056] Next, the film thickness of the optical film of the hole transport layer on the anode side of the aforementioned (b) was designed in accordance with the thickness of the optical film for emitting light predominantly composed of the desired wavelength λ of each organic EL element and the setting method. With the thickness of the aforementioned cathode side film being fixed to the setting, the film thickness of the hole transport layer was set so as to allow the desired amount of light to be emitted. The results are shown in Table 2.

Table 2

Light emitting layer	Thickness (nm)	Organic compound material	Peak wave-length (nm)	TPD common layer 42a (nm)	TPD common layer (nm)
43B	30	PC-7 **	480	40	-
43G	60	Alq	530	40	20 (42G)
43R	40	Alq : DCM*	620	40	45 (42R)

[0057] Table 3 shows the specifications of the organic EL multi-color display that was fabricated.

Table 3

	Transparent electrode (3) [Material/thickness(nm)]	Hole transport layer common layer(42a) [Material/ thickness (nm)]	Hole transport layer complement ary layer [Material/ thickness (nm)]	Light emitting layer [Material/ thickness (nm)]	Electron transport layer [Material/ thickness (nm)]
B	ITO/100	TPD/ 40	---	PC-7* * /30 (43B)	Alq /20 (44B)
G	ITO/100	TPD/ 40	TPD/20(42G)	Alq/60 (43G, 44G)	
R	ITO/100	TPD/ 40	TPD/45(42R)	Alq : DCM*/40 (43R)	Alq /30 (44R)

Claims

1. An organic electroluminescence multi-color display device comprising:

a light-transmitting substrate (2); and

a plurality of organic electroluminescence elements (1) formed on the light-transmitting substrate, wherein each of the organic electroluminescence elements includes
 a transparent electrode (3) formed on the light-transmitting substrate,
 a plurality of organic compound material layers (42a, 43B, 42G, 42R, 43G, 43R) layered on the transparent
 5 electrode, the plurality of organic compound material layers including a light emitting layer (43B, 43G, or 43R)
 and a hole transport functional layer and/or an electron transport functional layer and
 a metal electrode (5) layered on the plurality of organic compound material layers,

wherein the transparent electrodes (3) in neighboring organic electroluminescence elements have the same thick-
 10 ness as one another,

wherein the light emitting layers (43B, 43G, 43R) in neighboring organic electroluminescence elements are made
 of different organic compound materials so as to take on different colors of light emission respectively,
 wherein the light-emitting layer includes a light-emitting interface (10) for emitting light having a wavelength of λ
 serving as a primary component, the light emitting interface partitioning the organic compound material layers into
 15 a transparent electrode side portion and a metal electrode side portion in the organic compound material layers,
 the light-emitting interface (10) corresponding to an interface of the light emitting layer (43B, 43G, or 43R) close to
 the transparent electrode (3),

characterized in that, the organic electroluminescence elements have a continuous common hole and/or electron
 transport functional layer made of an organic compound material with a constant thickness wherein some or all of
 20 the organic electroluminescence elements have additional hole and/or electron transport functional layers stacked
 on said common layer having different thicknesses depending on the color emitted by the organic electrolumines-
 cence element, said thicknesses being set so that the transparent electrode side portion is deposited to have a film
 thickness such that an optical distance from the light-emitting interface (10) to an interface between the light-trans-
 mitting substrate and the transparent electrode is equal to even multiples of one-quarter of the wavelength λ .

2. An organic electroluminescence multi-color display device according to claim 1, wherein the organic compound
 material layers have layers made of the same organic compound material in the neighboring organic electrolumi-
 nescence elements.

3. An organic electroluminescence multi-color display device according to claim 1, wherein the additional layers are
 made of the same organic compound material as that of the continuous layer.

4. An organic electroluminescence multi-color display device according to claim 1, wherein the additional layers are
 made of organic compound materials different from that of the continuous layer.

5. An organic electroluminescence multi-color display device according to claim 1, wherein the continuous layer is a
 hole transport layer.

6. An organic electroluminescence multi-color display device according to claim 5, further comprising a hole injecting
 layer stacked in between the hole transport layer and the transparent electrode as an anode.

7. An organic electroluminescence multi-color display device according to claim 1, wherein the continuous layer is an
 electron transport layer.

8. An organic electroluminescence multi-color display device according to claim 7, further comprising an electron
 injection layer stacked in between said electron transport layer and the transparent electrode as a cathode.

9. An organic electroluminescence multi-color display device according to any one of claims 1-8, wherein the metal
 electrode side portion is deposited to have a film thickness such that an optical distance from the light-emitting
 50 interface (10) to an interface between the organic compound material layers and the metal electrode is equal to odd
 multiples of one quarter of the wavelength λ .

10. A method for fabricating an organic electroluminescence multi-color display device, the display device including a
 plurality of organic electroluminescence elements (1) formed on a light-transmitting substrate (2), each of the organic
 electroluminescence elements including transparent electrode and metal electrode (3, 5) and a light-emitting layer
 (43B, 43G, or 43R) and a hole transport functional layer and/or an electron transport functional layer,
 55 the method comprising the steps of:

forming respective transparent electrodes (3) on the light-transmitting substrate (2);
 stacking a plurality of organic compound material layers (42a, 43B, 42G, 42R, 43G, 43R) on the respective
 transparent electrodes, and
 forming metal electrodes (5) layered on the plurality of organic compound material layers,

wherein, in the forming step forming the transparent electrodes, the transparent electrodes (3) are formed to have the same thickness as one another, and

wherein the stacking step includes respective plural steps layering the organic compound material layers in such a manner that the organic compound material layers includes light emitting layers (43B, 43G, 43R) which are made of different organic compound materials so as to take on different colors of light emission in neighboring organic electroluminescence elements, and

wherein in the stacking step, the light-emitting layer is formed to include a light-emitting interface (10) for emitting light having wavelength of λ serving as a primary component, the light emitting interface partitioning the organic compound material layers into a transparent electrode side portion and a metal electrode side portion in the organic compound material layers, the light-emitting interface (10) corresponding to the interface of the light emitting layer (43B, 43G, or 43R) close to the transparent electrode (3),

characterized in that, the organic electroluminescence elements have a continuous common hole and/or electron transport functional layer made of an organic compound material with a constant thickness wherein some or all of the organic electroluminescence elements have additional hole and/or electron transport functional layers stacked on said common layer having different thicknesses depending on the color emitted by the organic electroluminescence element, said thicknesses being set so that the transparent electrode side portion is deposited to have a film thickness such that an optical distance from the light-emitting interface (10) to an interface between the light-transmitting substrate and the transparent electrode is equal to even multiples of one-quarter of the wavelength λ .

11. A method according to claim 10, wherein the additional layers are formed from the same organic compound material as that of the continuous layer.

12. A method according to claim 10, wherein the additional layer is formed from an organic compound material different from that of the continuous layer.

13. A method according to claim 10, wherein the continuous layer is a hole transport layer.

14. A method according to claim 13, wherein a hole injecting layer is stacked in between the hole transport layer and the transparent electrode as an anode.

15. A method according to claim 10, wherein the continuous layer is an electron-transport layer.

16. A method according to claim 15, wherein an electron injecting layer is stacked in between electron transport layer and the transparent electrode as a cathode.

17. A method according to claim 10, wherein the metal electrode side portion is deposited to have a film thickness such that an optical distance from the light-emitting interface (10) to an interface between the organic compound material layers and the metal electrode is equal to odd multiples of one quarter of the wavelength λ .

18. A method according to claim 10, wherein the organic compound material layers are stacked by vapor deposition using a mask.

Patentansprüche

1. Organische Elektrolumineszenz-Mehrfarbanzeigevorrichtung umfassend:

ein lichtübertragendes Substrat (2); und

eine Vielzahl von organischen Elektrolumineszenzelementen (1), die an dem lichtübertragenden Substrat gebildet sind, wobei jedes der organischen Elektrolumineszenzelemente aufweist

eine transparente Elektrode (3), die an dem lichtübertragenden Substrat gebildet ist, eine Vielzahl von organischen Verbundwerkstoffschichten (42a, 43B, 42G, 42R, 43G, 43R), die an der transparenten Elektrode in Schichten angeordnet sind, wobei die Vielzahl von organischen Verbundwerkstoffschichten eine lichtemittierende

rende Schicht (43B, 43G, oder 43R) und eine Lochtransportfunktionsschicht und/oder eine Elektronentransportfunktionsschicht aufweist, und
eine Metallelektrode (5), die als Schicht an der Vielzahl von organischen Verbundwerkstoffschichten angeordnet ist,

wobei die transparenten Elektroden (3) in benachbarten organischen Verbundwerkstoffelementen die gleiche Dicke untereinander haben,

wobei die lichtemittierenden Schichten (43B, 43G, 43R) in benachbarten organischen Elektrolumineszenzelementen aus verschiedenen organischen Verbundwerkstoffen so gefertigt sind, dass sie jeweils verschiedene Farben der Lichtemission annehmen,

wobei die lichtemittierende Schicht eine lichtemittierende Grenzfläche (10) für die Lichtemission einschließt, die eine Wellenlänge λ aufweist, die als eine Hauptkomponente dient, wobei die Grenzfläche (10) die organischen Verbundwerkstoffschichten in einen Abschnitt auf der Seite der transparenten Elektrode und einen Abschnitt auf der Seite der Metallelektrode in den organischen Verbundwerkstoffschichten teilt, wobei die lichtemittierende Grenzfläche (10) einer Grenzfläche der lichtemittierenden Schicht (43B, 43G, oder 43R) entspricht, die nahe an der transparenten Elektrode (3) vorgesehen ist,

dadurch gekennzeichnet, dass

die organischen Elektrolumineszenzelemente ein durchgehendes gemeinsames Loch-und/oder eine Elektronentransportfunktionsschicht aufweisen, die aus einem organischen Verbundwerkstoffmaterial mit einer konstanten Dicke gefertigt ist, wobei manche oder alle der organischen Elektrolumineszenzelemente zusätzliche Lochtransport- und/oder Elektronentransportfunktionsschichten aufweisen, die auf der gemeinsamen Schicht gestapelt sind und in Abhängigkeit von der Farbe, die von dem organischen Elektrolumineszenzelement emittiert wird, verschiedene Dicken aufweisen, die so eingestellt sind, dass der Abschnitt auf der Seite der transparenten Elektrode so aufgetragen ist, dass er eine Filmdicke aufweist, so dass ein optischer Abstand von der lichtemittierenden Grenzfläche (10) zu einer Grenzfläche zwischen dem lichtübertragenden Substrat und der transparenten Elektrode gleich geraden Vielfachen eines Viertels der Wellenlänge λ ist.

2. Organisches Elektrolumineszenz-Mehrfarbanzeigevorrichtung nach Anspruch 1, wobei die organischen Verbundwerkstoffschichten Schichten aufweisen, die aus dem gleichen organischen Verbundwerkstoff in den benachbarten organischen Elektrolumineszenzelementen gefertigt sind.
3. Organisches Elektrolumineszenz-Mehrfarbanzeigevorrichtung nach Anspruch 1, wobei die zusätzlichen Schichten aus dem gleichen organischen Verbundwerkstoff wie dem der durchgehenden Schicht gefertigt sind.
4. Organisches Elektrolumineszenz-Mehrfarbanzeigevorrichtung nach Anspruch 1, wobei die zusätzlichen Schichten aus anderen organischen Verbundwerkstoffen als dem der durchgehenden Schicht gefertigt sind.
5. Organisches Elektrolumineszenz-Mehrfarbanzeigevorrichtung nach Anspruch 1, wobei die durchgehende Schicht eine Lochtransportschicht ist.
6. Organisches Elektrolumineszenz-Mehrfarbanzeigevorrichtung nach Anspruch 5, weiter umfassend eine Lochinjektionsschicht, die in Form einer Schicht zwischen der Lochtransportschicht und der transparenten Elektrode als Anode angeordnet ist.
7. Organisches Elektrolumineszenz-Mehrfarbanzeigevorrichtung nach Anspruch 1, wobei die durchgehende Schicht eine Elektronentransportschicht ist.
8. Organisches Elektrolumineszenz-Mehrfarbanzeigevorrichtung nach Anspruch 7, weiter umfassend eine Elektroneninjektionsschicht, die in Form einer Schicht zwischen der Elektronentransportschicht und der transparenten Elektrode als Kathode angeordnet ist.
9. Organisches Elektrolumineszenz-Mehrfarbanzeigevorrichtung nach einem der Ansprüche 1-8, wobei der Abschnitt auf der Seite der Metallelektrode so aufgetragen ist, dass er eine Filmdicke aufweist, so dass ein optischer Abstand von der lichtemittierenden Grenzfläche (10) zu einer Grenzfläche zwischen den organischen Verbundwerkstoffschichten und der Metallelektrode gleich ungeraden Vielfachen eines Viertels der Wellenlänge λ ist.

10. Verfahren zum Herstellen einer organischen Elektrolumineszenz-Mehrfarbanzeigevorrichtung, wobei die Anzeigeeinrichtung eine Vielzahl von organischen Elektrolumineszenzelementen (1) aufweist, die an einem lichtemittierenden Substrat (2) gebildet sind, wobei jedes der organischen Elektrolumineszenzelemente eine transparente Elektrode und eine Metallelektrode (3, 5) und eine lichtemittierende Schicht (43B, 43G oder 43R) und eine Lochtransportfunktionsschicht and/oder eine Elektronentransportfunktionsschicht aufweist, wobei das Verfahren folgende Schritte aufweist:

das Bilden jeweiliger transparenten Elektroden (3) an dem lichtemittierenden Substrat (2);
 das Anordnen in Schichten einer Vielzahl organischer Verbundwerkstoffschichten (42a, 43B, 42G, 42R, 43G, 43R) an den jeweiligen transparenten Elektroden und
 das Bilden von Metallelektroden (5), die an der Vielzahl organischer Verbundwerkstoffschichten in Schichten angeordnet sind,

wobei im Schritt des Bildens zum Bilden der transparenten Elektroden (3) diese so gebildet sind, dass sie die gleiche Dicke untereinander haben, und
 wobei der Schritt des Anordnens in Schichten jeweilige mehrere Schritte zum Anordnen in Schichten der organischen Verbundwerkstoffschichten so aufweist, dass die organischen Verbundwerkstoffschichten lichtemittierende Schichten (43B, 43G, 43R) aufweisen, die aus verschiedenen organischen Verbundwerkstoffen so gefertigt sind, dass sie verschiedene Farben der Lichtemission in benachbarten organischen Elektrolumineszenzelementen annehmen, und

wobei in dem Schritt des Anordnens in Schichten die lichtemittierende Schicht gebildet ist, um eine lichtemittierende Grenzfläche (10) für die Lichtemission mit einer Wellenlänge λ einzuschließen, die als eine Hauptkomponente dient, wobei die lichtemittierende Grenzfläche (10) die organischen Verbundwerkstoffschichten in einen Abschnitt auf der Seite der transparenten Elektrode und einen Abschnitt auf der Metallelektrodenseite in den organischen Verbundwerkstoffschichten trennt, wobei die lichtemittierende Grenzfläche (10) der Grenzfläche der lichtemittierenden Schicht (43B, 43G, oder 43R) entspricht, die nahe an der transparenten Elektrode (3) vorgesehen ist,

dadurch gekennzeichnet, dass

die organischen Elektrolumineszenzelemente eine durchgehende gemeinsame Loch-und/oder eine Elektronentransportfunktionsschicht aufweisen, die aus einem organischen Verbundwerkstoffmaterial mit einer konstanten Dicke gefertigt ist, wobei manche oder alle der organischen Elektrolumineszenzelemente zusätzliche Loch-und/oder Elektronentransportfunktionsschichten aufweisen, die auf der gemeinsamen Schicht in Schichten angeordnet sind und in Abhängigkeit von der Farbe, die von dem organischen Elektrolumineszenzelement emittiert wird, verschiedene Dicken aufweisen, wobei die Dicken so eingestellt sind, dass der Abschnitt auf der Seite der transparenten Elektrode so aufgetragen ist, dass er eine Filmdicke aufweist, so dass ein optischer Abstand von der lichtemittierenden Grenzfläche (10) zu einer Grenzfläche zwischen dem lichtübertragenden Substrat und der transparenten Elektrode gleich geraden Vielfachen eines Viertels der Wellenlänge λ ist.

11. Verfahren nach Anspruch 10, wobei die zusätzlichen Schichten aus dem gleichen organischen Verbundwerkstoff wie dem der durchgehenden Schicht gefertigt sind.

12. Verfahren nach Anspruch 10, wobei die zusätzliche Schicht aus einem anderen organischen Verbundwerkstoff als dem der durchgehenden Schicht gefertigt ist.

13. Verfahren nach Anspruch 10, wobei die durchgehende Schicht eine Lochtransportschicht ist.

14. Verfahren nach Anspruch 13, wobei eine Lochinjektionsschicht in Form einer Schicht zwischen der Lochtransportschicht und der Transparentelektrode als Anode angeordnet ist.

15. Verfahren nach Anspruch 10, wobei die durchgehende Schicht eine Elektronentransportschicht ist.

16. Verfahren nach Anspruch 15, wobei eine Elektroneninjectionsschicht in Form einer Schicht zwischen der Elektronentransportschicht und der transparenten Elektrode als Kathode angeordnet ist.

17. Verfahren nach Anspruch 10, wobei der Abschnitt auf der Metallelektrodenseite so aufgetragen ist, dass er eine Filmdicke aufweist, so dass ein optischer Abstand von der lichtemittierenden Grenzfläche (10) zu einer Grenzfläche zwischen den organischen Verbundwerkstoffschichten und der Metallelektrode gleich ungeraden Vielfachen eines Viertels der Wellenlänge λ ist.

18. Verfahren nach Anspruch 10, wobei die organischen Verbundwerkstoffschichten mittels Gasphasenabscheidung unter Verwendung einer Maske schichtweise angeordnet sind.

Revendications

1. Dispositif d'affichage organique électroluminescent multicolore comprenant :

un substrat de transmission de lumière (2) ; et

une pluralité d'éléments organiques électroluminescents (1) formés sur le substrat de transmission de lumière, dans lequel chacun des éléments organiques électroluminescents comprend

- une électrode transparente (3) formée sur le substrat de transmission de lumière,
- une pluralité de couches de matériaux de composés organiques (42a, 43B, 42G, 42R, 43G, 43R) stratifiées sur l'électrode transparente, la pluralité de couches de matériaux de composés organiques comprenant une couche d'émission de lumière (43B, 43G ou 43R) et une couche fonctionnelle de transport de trous et/ou une couche fonctionnelle de transport d'électrons, et
- une électrode en métal (5) stratifiée sur la pluralité de couches de matériaux de composés organiques,

dans lequel les électrodes transparentes (3) dans des éléments organiques électroluminescents voisins ont la même épaisseur l'une que l'autre,

dans lequel les couches d'émission de lumière (43B, 43G, 43R) dans des éléments organiques électroluminescents voisins sont constituées de différents matériaux de composés organiques de manière à prendre respectivement différentes couleurs d'émission de lumière,

dans lequel la couche d'émission de lumière comprend une interface d'émission de lumière (10) pour émettre de la lumière ayant une longueur d'onde de λ servant de composante primaire, l'interface d'émission de lumière partitionnant les couches de matériaux de composés organiques en une portion de côté d'électrode transparente et une portion de côté d'électrode en métal dans les couches de matériaux de composés organiques, l'interface d'émission de lumière (10) correspondant à une interface de la couche d'émission de lumière (43B, 43G ou 43R) à proximité de l'électrode transparente (3),

caractérisé en ce que, les éléments organiques électroluminescents ont une couche fonctionnelle continue commune de transport de trous et/ou d'électrons constituée d'un matériau de composé organique d'une épaisseur constante, dans lequel certains ou l'ensemble des éléments organiques électroluminescents ont des couches fonctionnelles de transport de trous et/ou d'électrons supplémentaires empilées sur ladite couche commune ayant des épaisseurs différentes en fonction de la couleur émise par l'élément organique électroluminescent, lesdites épaisseurs étant réglées de sorte que la portion de côté d'électrode transparente soit déposée pour avoir une épaisseur de film telle qu'une distance optique de l'interface d'émission de lumière (10) à une interface entre le substrat de transmission de lumière et l'électrode transparente soit égale à des multiples pairs d'un quart de la longueur d'onde λ .

2. Dispositif d'affichage organique électroluminescent multicolore selon la revendication 1, dans lequel les couches de matériaux de composés organiques ont des couches constituées du même matériau de composé organique dans les éléments organiques électroluminescents voisins.

3. Dispositif d'affichage organique électroluminescent multicolore selon la revendication 1, dans lequel les couches supplémentaires sont constituées des mêmes matériaux de composés organiques que ceux de la couche continue.

4. Dispositif d'affichage organique électroluminescent multicolore selon la revendication 1, dans lequel les couches supplémentaires sont constituées de matériaux de composés organiques différents de ceux de la couche continue.

5. Dispositif d'affichage organique électroluminescent multicolore selon la revendication 1, dans lequel la couche continue est une couche de transport de trous.

6. Dispositif d'affichage organique électroluminescent multicolore selon la revendication 5, comprenant en outre une couche d'injection de trous empilée entre la couche de transport de trous et l'électrode transparente en tant qu'anode.

7. Dispositif d'affichage organique électroluminescent multicolore selon la revendication 1, dans lequel la couche continue est une couche de transport d'électrons.

8. Dispositif d'affichage organique électroluminescent multicolore selon la revendication 7, comprenant en outre une couche d'injection d'électrons empilée entre ladite couche de transport d'électrons et l'électrode transparente en tant que cathode.

9. Dispositif d'affichage organique électroluminescent multicolore selon l'une quelconque des revendications 1 à 8, dans lequel la portion de côté d'électrode en métal est déposée pour avoir une épaisseur de film telle qu'une distance optique de l'interface d'émission de lumière (10) à une interface entre les couches de matériaux de composés organiques et l'électrode en métal soit égale à des multiples impairs d'un quart de la longueur d'onde λ .

10. Procédé pour fabriquer un dispositif d'affichage organique électroluminescent multicolore, le dispositif d'affichage comprenant une pluralité d'éléments organiques électroluminescents (1) formés sur un substrat de transmission de lumière (2), chacun des éléments organiques électroluminescents comprenant une électrode transparente et une électrode en métal (3, 5) et une couche d'émission de lumière (43B, 43G, ou 43R) et une couche fonctionnelle de transport de trous et/ou une couche fonctionnelle de transport d'électrons,

le procédé comprenant les étapes consistant à :

former des électrodes transparentes respectives (3) sur le substrat de transmission de lumière (2) ;
empiler une pluralité de couches de matériaux de composés organiques (42a, 43B, 42G, 42R, 43G, 43R) sur les électrodes transparentes respectives, et
former des électrodes métalliques (5) stratifiées sur la pluralité de couches de matériaux de composés organiques,

dans lequel, à l'étape de formation consistant à former les électrodes transparentes, les électrodes transparentes (3) sont formées pour avoir la même épaisseur l'une que l'autre, et

dans lequel l'étape d'empilage comprend plusieurs étapes respectives de stratification des couches de matériaux de composés organiques de sorte que les couches de matériaux de composés organiques comprennent des couches d'émission de lumière (43B, 43G, 43R) qui sont constituées de différents matériaux de composés organiques de manière à prendre différentes couleurs d'émission de lumière dans des éléments organiques électroluminescents voisins, et

dans lequel, à l'étape d'empilage, la couche d'émission de lumière est formée pour comprendre une interface d'émission de lumière (10) pour émettre de la lumière ayant une longueur d'onde de λ servant de composante primaire, l'interface d'émission de lumière partitionnant les couches de matériaux de composés organiques en une portion de côté d'électrode transparente et une portion de côté d'électrode en métal dans les couches de matériaux de composés organiques, l'interface d'émission de lumière (10) correspondant à une interface de la couche d'émission de lumière (43B, 43G ou 43R) à proximité de l'électrode transparente (3),

caractérisé en ce que, les éléments organiques électroluminescents ont une couche fonctionnelle continue commune de transport de trous et/ou d'électrons constituée d'un matériau de composé organique d'une épaisseur constante, dans lequel certains ou l'ensemble des éléments organiques électroluminescents ont des couches fonctionnelles de transport de trous et/ou d'électrons supplémentaires empilées sur ladite couche commune ayant des épaisseurs différentes en fonction de la couleur émise par l'élément organique électroluminescent, lesdites épaisseurs étant réglées de sorte que la portion de côté d'électrode transparente soit déposée pour avoir une épaisseur de film telle qu'une distance optique de l'interface d'émission de lumière (10) à une interface entre le substrat de transmission de lumière et l'électrode transparente soit égale à des multiples pairs d'un quart de la longueur d'onde λ .

11. Procédé selon la revendication 10, dans lequel les couches supplémentaires sont constituées du même matériau de composé organique que celui de la couche continue.

12. Procédé selon la revendication 10, dans lequel la couche supplémentaire est constituée d'un matériau de composé organique différent de celui de la couche continue.

13. Procédé selon la revendication 10, dans lequel la couche continue est une couche de transport de trous.

14. Procédé selon la revendication 13, dans lequel une couche d'injection de trous est empilée entre la couche de transport de trous et l'électrode transparente en tant qu'anode.

15. Procédé selon la revendication 10, dans lequel la couche continue est une couche de transport d'électrons.

16. Procédé selon la revendication 15, dans lequel une couche d'injection d'électrons est empilée entre ladite couche

de transport d'électrons et l'électrode transparente en tant que cathode.

5 17. Procédé selon la revendication 10, dans lequel la portion de côté d'électrode en métal est déposée pour avoir une épaisseur de film telle qu'une distance optique de l'interface d'émission de lumière (10) à une interface entre les couches de matériaux de composés organiques et l'électrode en métal soit égale à des multiples impairs d'un quart de la longueur d'onde λ .

10 18. Procédé selon la revendication 10, dans lequel les couches de matériaux de composés organiques sont empilées par dépôt de vapeur en utilisant un masque.

10

15

20

25

30

35

40

45

50

55

FIG.1

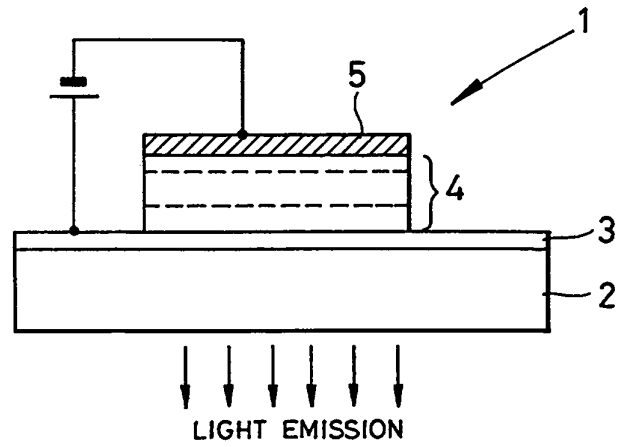


FIG.2

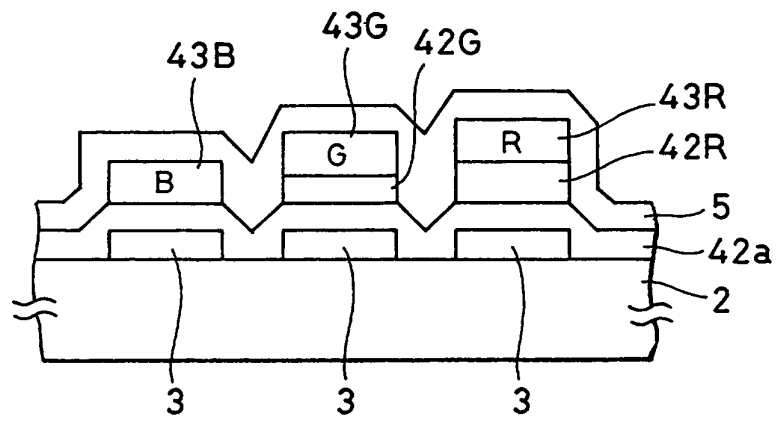


FIG.3

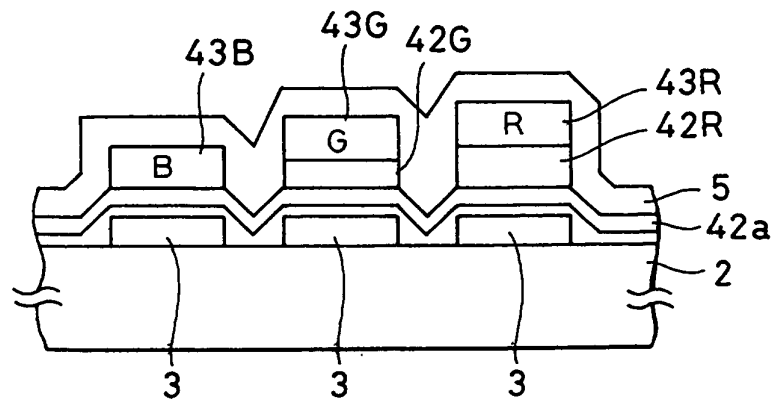


FIG. 4

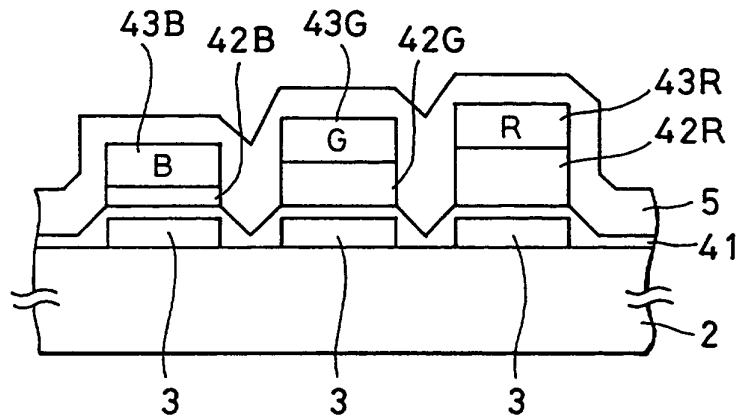


FIG. 5

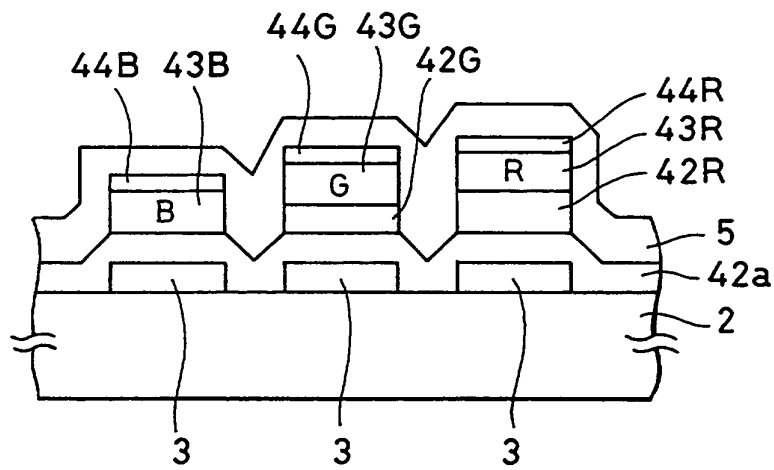


FIG. 6

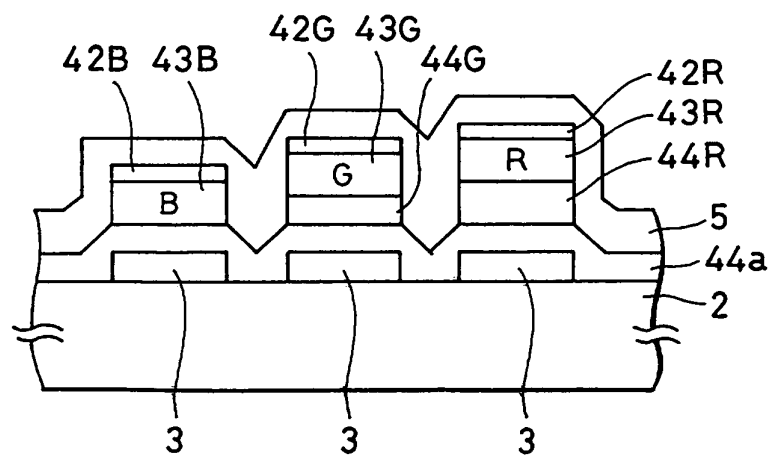


FIG. 7

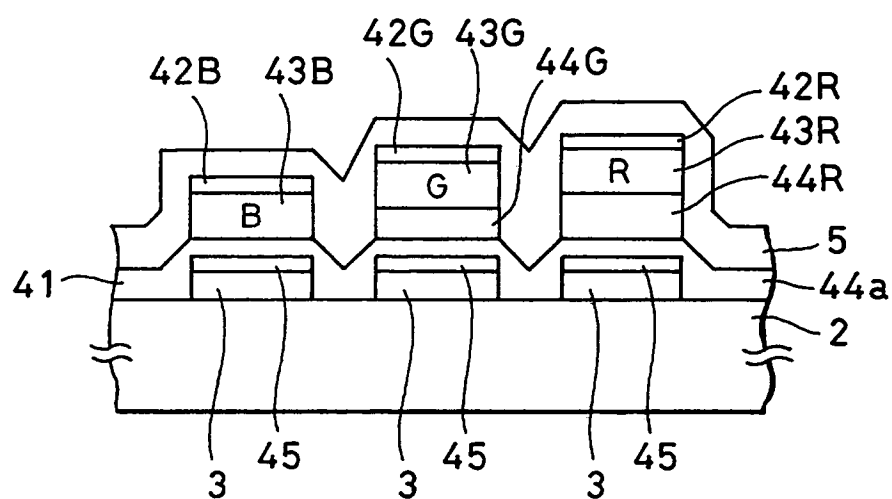


FIG. 8

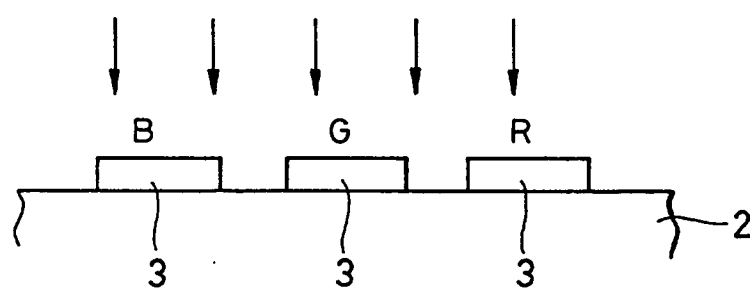


FIG. 9

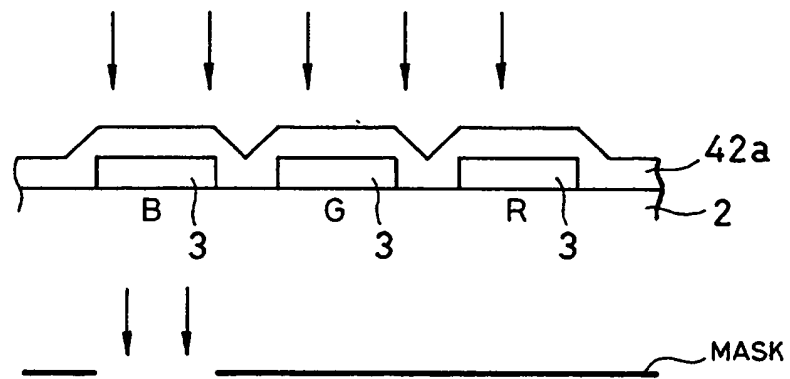


FIG. 10

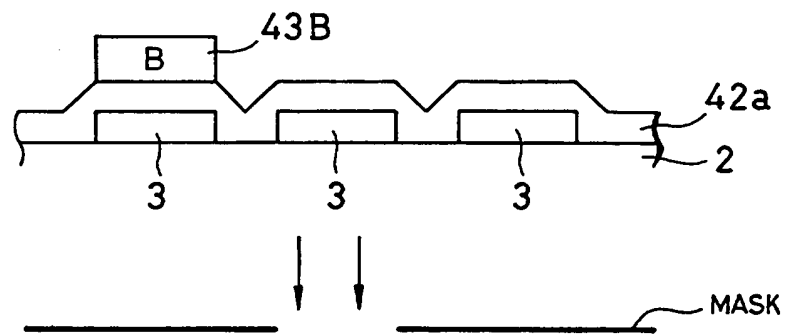


FIG. 11

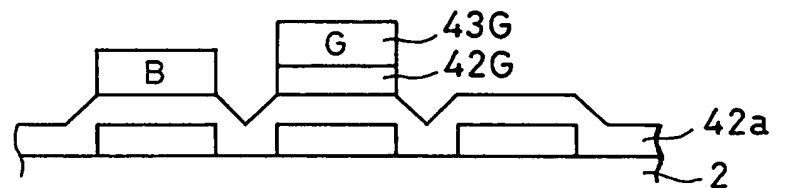


FIG. 12

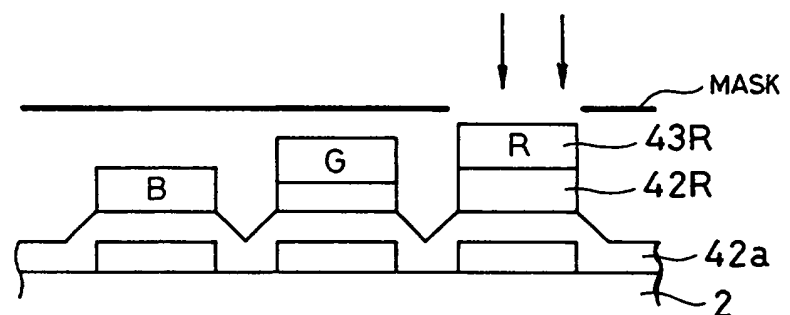


FIG. 13

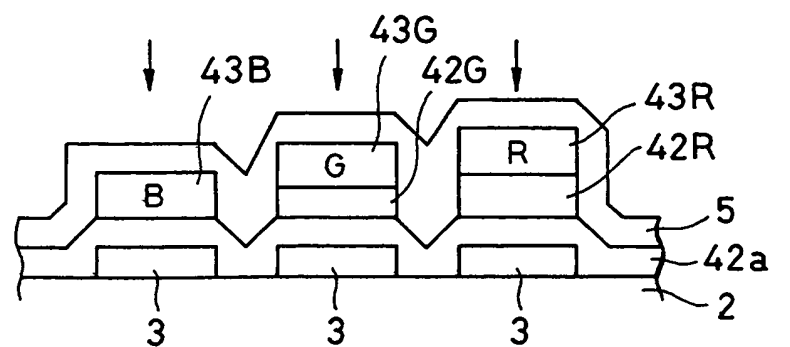


FIG.14

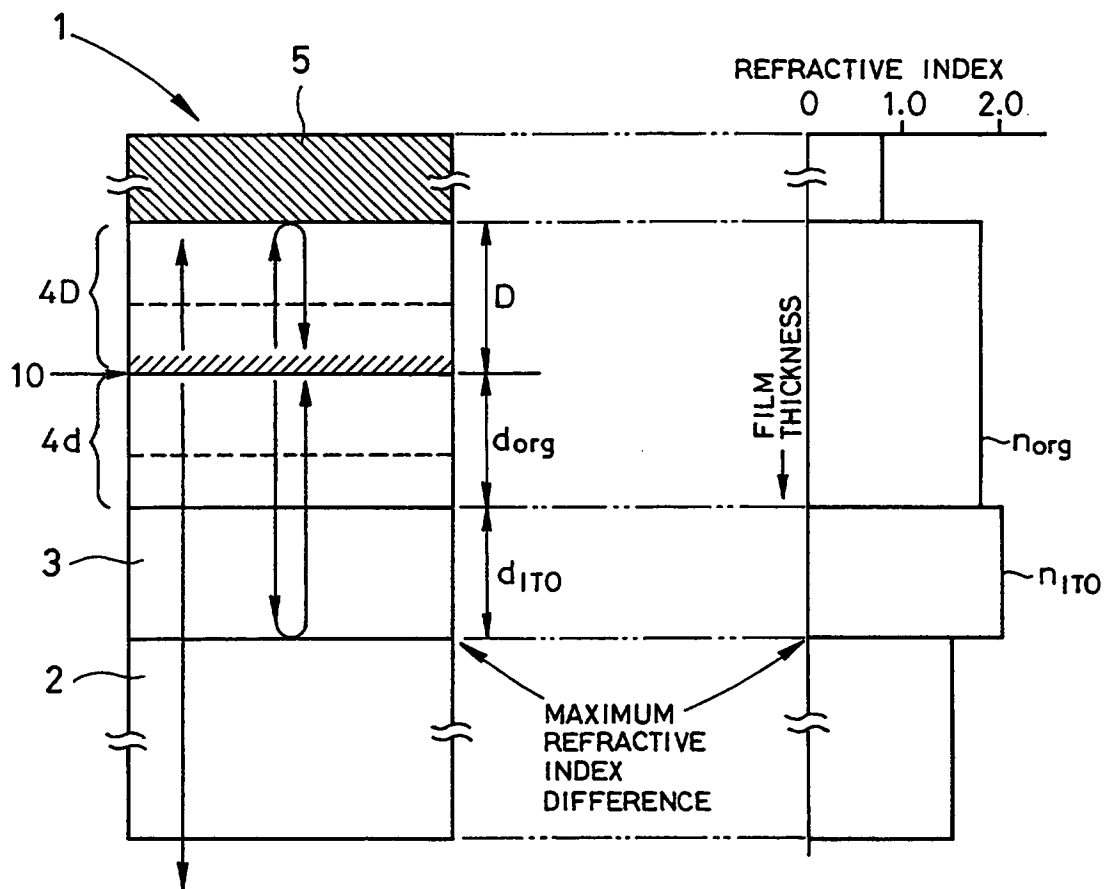


FIG. 15

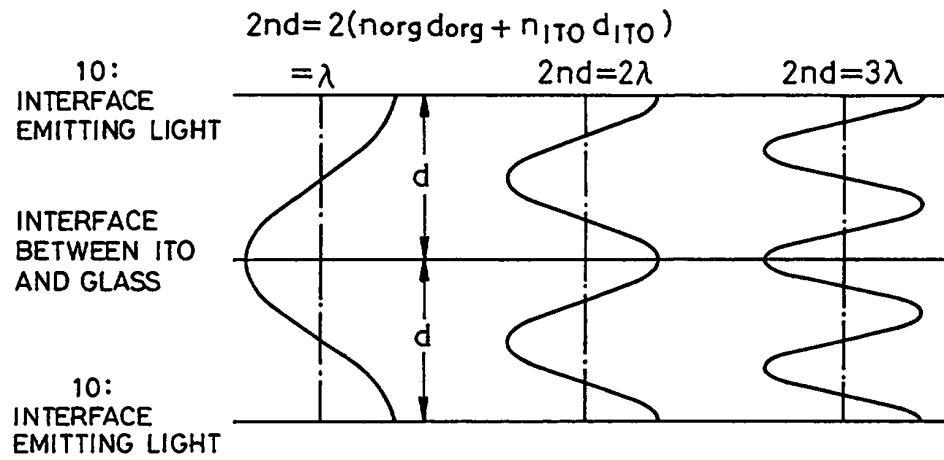


FIG. 16

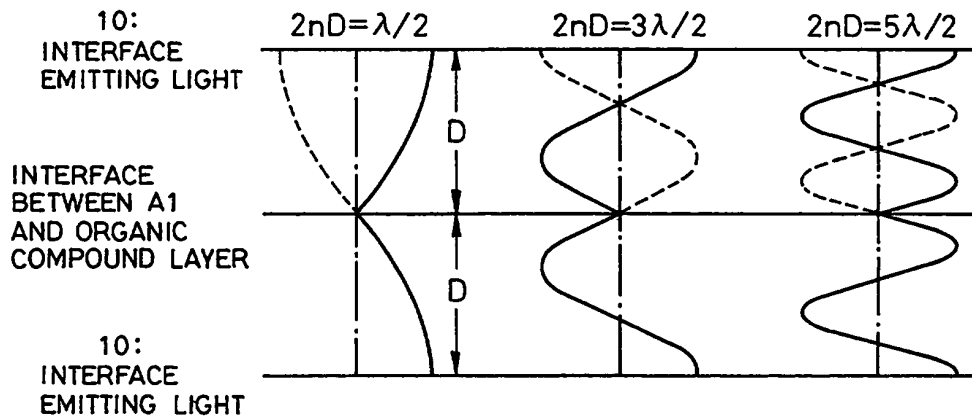


FIG. 17

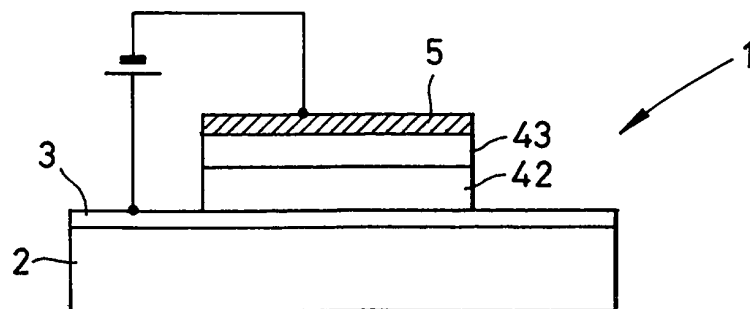


FIG.18

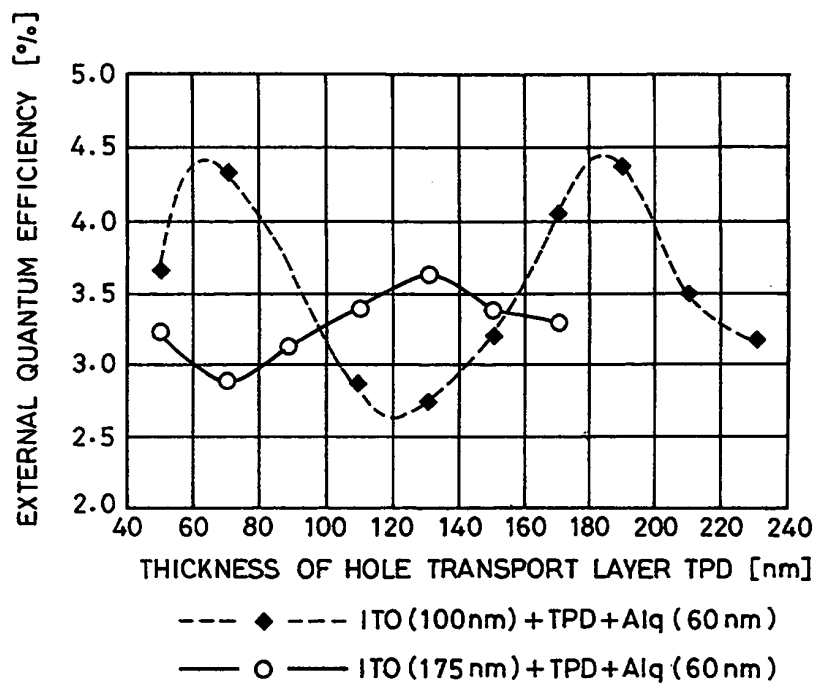


FIG.19

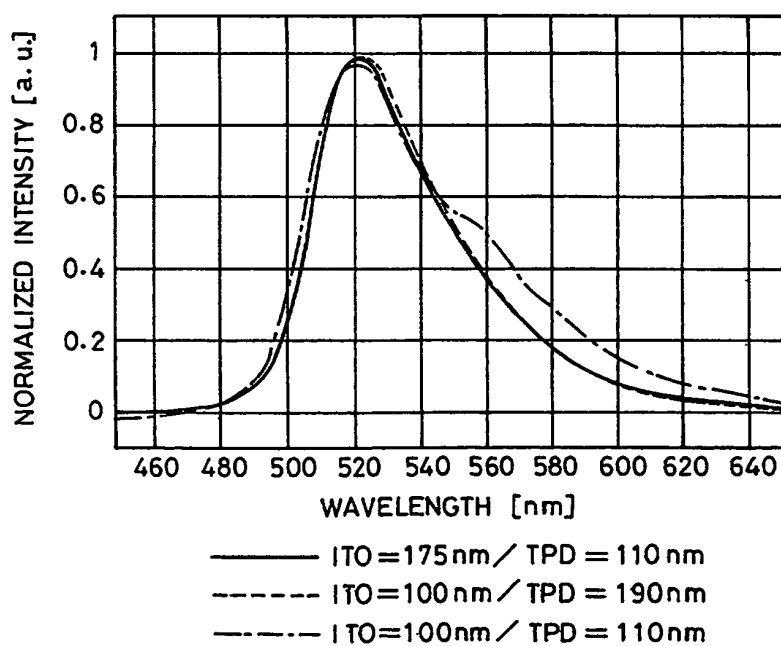


FIG. 20

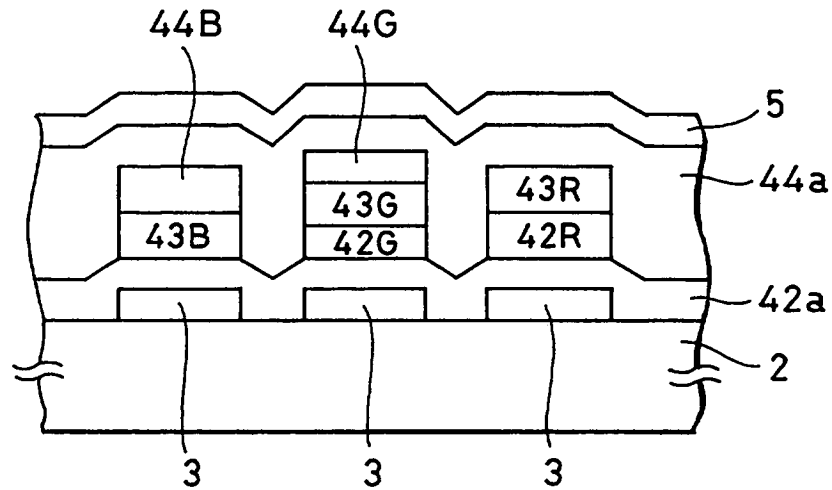
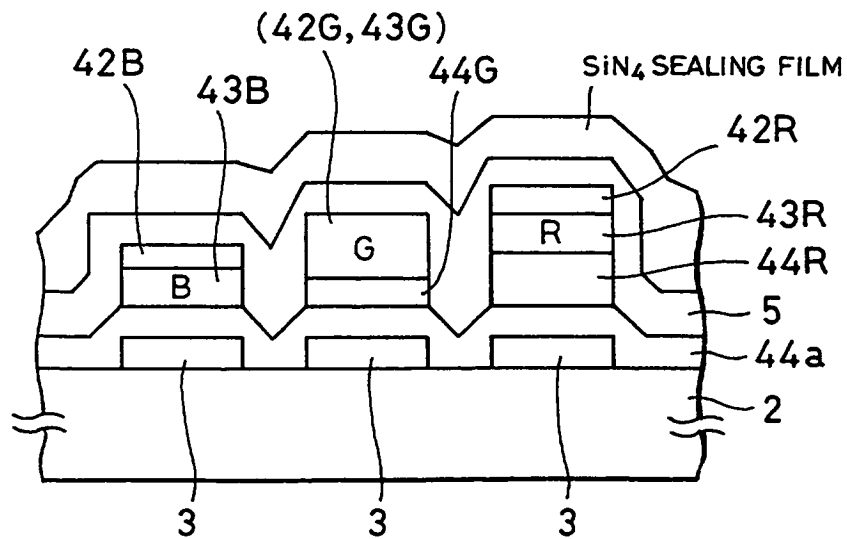


FIG. 21



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2846571 B [0003]
- US 5742129 A [0006]

专利名称(译)	有机电致发光多色显示器及其制造方法		
公开(公告)号	EP1052708B1	公开(公告)日	2009-04-22
申请号	EP2000110114	申请日	2000-05-10
[标]申请(专利权)人(译)	日本先锋公司		
申请(专利权)人(译)	先锋公司		
当前申请(专利权)人(译)	先锋公司		
发明人	FUKUDA, YOSHINORI, PIONEER CORPORATION		
IPC分类号	H01L27/32 H01L51/52 H05B33/12 H01L51/50 H05B33/10 H05B33/14 H05B33/24		
CPC分类号	H01L51/5262 H01L27/3211 H01L51/5265 H01L2251/558 Y10S428/917 Y10T428/24942		
优先权	1999131501 1999-05-12 JP		
其他公开文献	EP1052708A3 EP1052708A2		
外部链接	Espacenet		

摘要(译)

本发明公开了一种有机电致发光多色显示器，包括透明电极，至少包括发光层的多个有机化合物材料层，金属电极，依次堆叠在透明基板上，以及多个有机电致发光元件包括由不同有机化合物材料制成的发光层并具有不同颜色的发光。具有相同功能的除发光层之外的有机化合物材料层的每个功能层的厚度对应于发射光的颜色。

$$2nd = 2(n_{org}d_{org} + n_{mo}d_{mo})$$