



(51) International Patent Classification:

H01L 27/32 (2006.01) *H01L 51/54* (2006.01)
H01L 51/50 (2006.01) *H05B 33/14* (2006.01)

(21) International Application Number:

PCT/CN2013/086108

(22) International Filing Date:

29 October 2013 (29.10.2013)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

13/770,404 19 February 2013 (19.02.2013) US

(71) Applicant: **AU OPTRONICS CORPORATION**
[CN/CN]; No.1, Li-Hsin Road 2, Science-Based Industrial
Park, Hsin-Chu, Taiwan (CN).

(72) Inventors: **CHEN, Kueibai**; No.1, Li-Hsin Road 2, Sci-
ence-Based Industrial Park, Hsin-Chu, Taiwan (CN). **LI,**
Chiahao; No.1, Li-Hsin Road 2, Science-Based Industrial
Park, Hsin-Chu, Taiwan (CN). **LIAO, Chenhsien**; No.1,
Li-Hsin Road 2, Science-Based Industrial Park, Hsin-Chu,
Taiwan (CN).

(74) Agent: **LECOMME INTELLECTUAL PROPERTY**
AGENT LTD.; Floor. 16, Tower B of IN.DO Mansion
No. 48-Jia Zhichun Road, Haidian District, Beijing 100098
(CN).

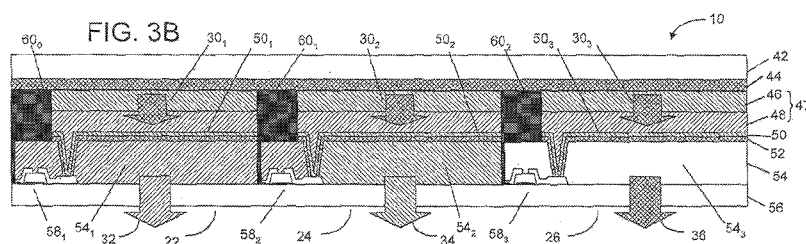
(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,
ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: MULTI-COLOR LIGHT EMITTING DIODE AND METHOD FOR MAKING SAME



(57) Abstract: A color light-emitting diode using a blue light component to produce red light and green light is disclosed. A blue-light emitting material provided between a cathode layer (44) and an anode layer (50) for emitting the blue light component. A light re-emitting layer (54) has a first material in a first diode section (54₁) arranged to produce a red light component in response to the blue light component, and a second material in a second diode section (54₂) arranged to produce a green light component in response to the blue light component. A transparent material in a third diode section (54₃) allows part of the blue light component to transmit through. The anode layer (50) is partitioned into three electrode portions separately located in the three diode sections, so that the red, green and blue light components in the diode sections can be separately controlled.

MULTI-COLOR LIGHT EMITTING DIODE AND METHOD FOR MAKING SAME

Field of the Invention

The present invention relates generally to a multi-color light-emitting diode and, more
5 specifically, to a light-emitting diode that is capable of emitting light in red, green and blue colors.

Background of the Invention

Light-Emitting Diodes (LEDs) and Organic Light-Emitting Diodes (OLEDs) have been used
in making color display panels. As with an LCD display, an OLED display produces color images
10 based on three primary colors in R, G and B. A color pixel in an OLED display can be made of an R
sub-pixel, a G sub-pixel and a B sub-pixel. In general, the brightness of the OLED material is
approximately proportional to current and, therefore, different colors and shades can be achieved by
controlling the currents. The advantage of OLEDs over Liquid-Crystal Display (LCD) includes the
fact that OLEDs are able to emit light whereas a pixel in an LCD acts as a light-valve mainly to
15 transmit light provided by a backlight unit. Thus, an LED/OLED panel can, in general, be made
thinner than an LCD panel. Furthermore, it is known that the liquid crystal molecules in an LCD
panel have slower response time. An OLED display also offers higher viewing angles, a higher
contrast ratio and higher electrical power efficiency than its LCD counterpart.

A typical color display panel has a plurality of pixels arranged in a two-dimensional array,
20 driven by a data driver and a gate driver. As shown in Figure 1, a plurality of pixels 10 in a display
panel 1 are arranged in rows and columns in a display area 100. A data driver 200 is used to provide
data signals to each of the columns and a gate driver 300 is used to provide a gate line signal to each
of the rows. In a color display panel, an image is generally presented in three colors: red (R), green
(G) and blue (B). Each of the pixels 10 is typically divided into three color sub-pixels: red sub-pixel,
25 green sub-pixel and blue sub-pixel.

The present invention is concerned with a color pixel having RGB sub-pixels and a method for
making same.

Summary of the Invention

The present invention provides a color light-emitting diode using a blue light component to produce red light and green light. In one embodiment of the present invention, a blue-light emitting material is provided between a cathode layer and an anode layer for emitting the blue light component. A light re-emitting layer has a first material in a first diode section arranged to produce a red light component in response to the blue light component, and a second material in a second diode section arranged to produce a green light component in response to the blue light component. A transparent material in a third diode section allows part of the blue light component to transmit through. The anode layer is partitioned into three electrode portions separately located in the three diode sections, so that the red, green and blue light components in the diode sections can be separately controlled.

Thus, the first aspect of the present invention is a light emitting diode, comprising:

- a first electrode layer;

- a second electrode layer;

- an organic layer disposed between the first and second electrode layers arranged to emit a first light component in a first wavelength through the second electrode layer;

- a light re-emitting layer adjacent to the second electrode layer, arranged to receive at least part of the first light component, the light re-emitting layer comprising a first excitable material arranged to emit a second light component in a second wavelength longer than the first wavelength in response to the first light component, and a second excitable material arranged to emit a third light component in a third wavelength longer than the second wavelength in response to the first light component. The first wavelength is in a wavelength range of 450nm to 480nm, the second wavelength is in a wavelength range of 490nm to 570nm, and the third wavelength is in a wavelength range of 590nm to 650nm. Alternatively, the first wavelength is in a wavelength range of 460nm to 520nm, the second wavelength is in a wavelength range of 490nm to 570nm, and the third wavelength is in a wavelength range of 590nm to 650nm.

The light emitting diode further comprises:

- a passivation layer between the light re-emitting layer and the second electrode layer;

- a first barrier and a second barrier arranged to partition the light emitting diode into a first diode section, a second diode section and a third diode section, the first barrier arranged to separate the first excitable material from the second excitable material in the light re-emitting layer such that the first excitable material is located in a first diode portion and the second excitable material is located in the second diode section; the second barrier arranged to separate the first excitable material

from the third diode section; the first and second barriers also arranged to partition the first electrode layer into a first electrode section in the first diode section, a second electrode section in the second diode section and a third electrode section in the third diode section; and

5 a first switching element connected to the first electrode section, a second switching element connected to the second electrode section and a third switching element connected to the third electrode section.

10 In one embodiment of the present invention, the light re-emitting layer further comprises a third material to transmit at least part of the first light component. In another embodiment of the present invention, the third material is arranged to provide a fourth light component in a fourth wavelength longer than the first wavelength but shorter than the second wavelength. The third material can be a color filter or an excitable material arranged to emit the fourth light component in response to the first light component. The first wavelength is in a wavelength range of 380nm to 480nm; the second wavelength is in a wavelength range of 490nm to 570nm; the third wavelength is in a wavelength range of 590nm to 650nm, and the fourth wavelength is in a wavelength range of 410nm to 480nm.

The second aspect of the present invention is a display panel, comprising:

a substrate;

a plurality of pixels formed on the substrate, each pixel comprising a light-emitting diode, the light-emitting diode comprising:

20 a first electrode layer;

a second electrode layer;

an organic layer disposed between the first and second electrode layers arranged to emit a first light component in a first wavelength through the second electrode layer;

25 a light re-emitting layer adjacent to the second electrode layer, arranged to receive at least part of the first light component, the light re-emitting layer comprising a first excitable material arranged to emit a second light component in a second wavelength longer than the first wavelength in response to the first light component, and a second excitable material arranged to emit a third light component in a third wavelength longer than the second wavelength in response to the first light component.

30 The third aspect of the present invention is a method for producing a light emitting diode, comprising:

providing a first electrode layer and a second electrode layer on a substrate;

disposing an organic layer between the first and second electrode layers, the organic layer arranged to emit a first light component in a first wavelength through the second electrode layer;

disposing a light re-emitting layer adjacent to the second electrode layer, the light re-emitting layer arranged to receive at least part of the first light component, the light re-emitting layer comprising a first excitable material arranged to emit a second light component in a second wavelength longer than the first wavelength in response to the first light component, and a second excitable material arranged to emit a third light component in a third wavelength longer than the second wavelength in response to the first light component.

The method further comprises:

providing a first barrier and a second barrier arranged to partition the light emitting diode into a first diode section, a second diode section and a third diode section, the first barrier arranged to separate the first excitable material from the second excitable material in the light re-emitting layer such that the first excitable material is located in a first diode portion and the second excitable material is located in the second diode section; the second barrier arranged to separate the first excitable material from the third diode section; the first and second barriers also arranged to partition the first electrode layer into a first electrode section in the first diode section, a second electrode section in the second diode section and a third electrode section in the third diode section; and

providing a first switching element connected to the first electrode section, a second switching element connected to the second electrode section and a third switching element connected to the third electrode section.

In one embodiment of the present invention, the method further comprises providing a color filter in the third diode section, the color filter configured to transmit at least part of the first light component.

Brief Description of the Drawings

Figure 1 shows a typical display panel having rows and columns of pixels in a display area.

Figure 2 shows a color pixel, according to one embodiment of the present invention.

Figure 3A shows a cross sectional view of the color pixel of Figure 2.

Figure 3B shows a graphical representation of the color pixel of Figure 3A when the pixel emits light.

Figure 4 shows a layered structure of a sub-pixel which is part of the color pixel of Figure 3A.

Figure 5 is a graphical representation of a quantum dot used in the color sub-pixels, according to one embodiment of the present invention.

5 **Detailed Description of the Invention**

In an OLED pixel, according to various embodiments of the present invention, the same luminescent layer is used as the light source for all three color sub-pixels. As shown in Figure 2, the color pixel 10 comprises three color sub-pixels 22, 24 and 26 for producing light in three colors R, G and B. Each color sub-pixel has a switching element such as a thin-film transistor (TFT) to activate
10 the color sub-pixel. As shown in Figure 3A, the color pixel 10 comprises a first substrate or protective layer 42, a first electrode layer 44, an organic layer 47, a second electrode layer 50, a passivation layer 52, a light re-emitting layer 54 and a second substrate 56. In one embodiment of the present invention, the first electrode layer 44 comprises a cathode layer; the second electrode layer 50 comprises an anode layer including anode portions 50₁, 50₂ and 50₃; and the organic layer 47
15 comprises a luminescent layer 46 and a hole injection layer 48. The luminescent layer 46 comprises a blue light-emitting material, for example. The light re-emitting layer 54 comprises a first layer portion 54₁ having red-light emitting material, and a second layer portion 54₂ having a green-light emitting material. The red-light emitting material is selected for emitting red light and the green-light emitting material is selected for emitting green light in response to the blue light emitted in
20 luminescent layer 46. The third layer portion 54₃ may comprise a material which is substantially transparent to blue light. The blue light is in a wavelength range of 450nm to 480nm; the green light is in a wavelength range of 490-570nm and the red light is in a wavelength range of 590nm to 650nm, for example.

In another embodiment of the present invention, the luminescent layer 46 comprises a blue-
25 greenish light-emitting material arranged to emit blue-greenish light in a wavelength range of 460-520nm. The third layer portion 54₃ may comprise a material which is substantially transparent to blue-greenish light in the wavelength range of 460-520nm or may comprise a blue color filter arranged to transmit blue light in the wavelength range of 450nm to 480nm.

In a different embodiment of the present invention, the luminescent layer 46 comprises a violet
30 light-emitting material, for example. The light re-emitting layer 54 comprises a first layer portion 54₁ having red-light emitting material; a second layer portion 54₂ having a green-light emitting material;

and a third layer portion 54₃ having a blue-light emitting material. The red-light emitting material is selected for emitting red light; the green-light emitting material is selected for emitting green light; and the blue-light emitting material is selected for emitting blue light in response to the violet light emitted in luminescent layer 46. The violet light is in a wavelength range of 380nm to 450nm; the blue light is in a wavelength range of 450nm to 480nm; the green light is in a wavelength range of 490-570nm and the red light is in a wavelength range of 590nm to 650nm, for example. In yet another embodiment, the violet light is in a wavelength range of 380nm to 480nm and the third layer portion 54₃ comprises a blue color filter arranged to transmit blue light in a wavelength range of 410nm to 480nm.

In each color pixel 10, two or more insulating barriers (BM) 60 are used to partition pixel 10 into three color sub-pixels 22, 24, and 26. As shown in Figures 3A and 3B, first barrier 60₁ is provided between color sub-pixels 22 and 24, and second barrier 60₂ is provided between color sub-pixels 24 and 26. As shown in Figures 3A, 3B and 4, color sub-pixel 22 also has another barrier 60₀. However, at least the first electrode layer 44 (used as a cathode) can be shared by the color sub-pixels 22, 24 and 26. According to one embodiment of the present invention, the color sub-pixels 22, 24 and 26 can have the same organic layers 47. In that case, the color sub-pixels 22, 24 and 26 can have the same luminescent layer 46 that comprises a blue-light emitting material. For example, the luminescent layer 46 may comprise organometallic complexes such as trivalent metal quinolate complexes, Schiff base divalent metal complexes, metal acetylacetonate complexes, metal bidentate ligand complexes, bisphosphonates, metal maleonitriledithiolate complexes, molecular charge transfer complexes, aromatic and heterocyclic polymers and rare earth mixed chelates or the like. The color sub-pixels 22, 24 and 26 have three switching elements such as thin-film transistors (TFTs) 58₁, 58₂ and 58₃ to control the color sub-pixels 22, 24 and 26. Each of the color sub-pixels 22, 24, 26 has its anode layer portions 50₁, 50₂, 50₃ separately connected to a switching element so that the brightness of each color sub-pixel can be individually controlled. When a voltage is applied between the common cathode layer 44 and the anode layer portion 50₁, 50₂, 50₃ in each of the color sub-pixels 22, 24, 26, blue light portions 30₁, 30₂, 30₃ emitted in the organic layer 47 are transmitted toward the light re-emitting layer 54 as shown in Figure 3B. It is understood that the amplitude or intensity of blue light portion 30₁ may be different from that of blue light portion 30₂, and blue light portion 30₃ depending on the applied voltage in the color sub-pixels 22, 24 and 26. As shown in Figure 4, the color sub-pixel 22 is used for producing red light. Thus, the first layer portion 54₁ in the color sub-

pixel 22 comprises a first excitable material arranged to produce light 32 in a longer wavelength range in response to the excitation of the blue light portion 30₁ (Figure 3B). The first excitable material in the first layer portion 54₁ in the color sub-pixel 22 may comprise 1-ethyl-2-[4-(p-dimethylaminophenyl)-1,3-butadienyl]pyridinium perchlorate, or 4-(Dicyanomethylene)-2-tert-butyl-6-(1,1,7,7-tetramethyljulolidyl-9-enyl)-4H-pyran. The longer wavelength range may cover a range of 590nm to 650nm. Similarly, the color sub-pixel 24 is used for producing green light. Thus, the second layer portion 54₂ in the color sub-pixel 24 comprises a second excitable material arranged to produce light 34 in a different wavelength range in response to the excitation of the blue light portion 30₂ (Figure 3B). The second excitable material in the second layer portion 54₂ in the color sub-pixel 24 may comprise Aluminum 8-hydroxyquinolate, Aluminum oxinate or 3-(2'-benzothiazolyl)-7-diethylaminocoumarin. This different wavelength range may cover a range of 490nm to 570nm. The blue light 30 may cover a wavelength range of 450nm to 480nm, but this range can be extended to the violet region of 380nm to 450nm.

It should be noted that the layered structure as shown in Figures 3A is only for illustrating the operating principle of the multi-color OLED, according to one embodiment of the present invention. It is understood that the pixel may comprise other layers such as hole transport layer (HTL), and electron transport layer (ETL). Furthermore, the multi-color pixel 10 can be constructed with the anode layer adjacent to the first substrate 42 and the cathode connected to TFT.

The anode layer 50 can be made of any one of the following metallic oxides or the combination thereof: indium-tin oxide, aluminum-doped zinc oxide, indium-doped zinc-oxide, tin-oxide, magnesium-tin oxide, nickel-tungsten oxide, cadmium-tin oxide and the like. The cathode layer can be made of any one of the following metals or the alloys thereof: aluminum, silver, magnesium-silver alloy and the like.

In a different embodiment of the present invention, quantum dots (see Figure 5) may be used in the light re-emitting layer 54 to produce light in response to the excitation of blue light portions 30₁, 30₂, 30₃. The size of the quantum dots in the first layer portion 54₁ in the color sub-pixel 22 is chosen to produce light in the wavelength range of 590nm to 650nm. Likewise, the size of the quantum dots in the second layer portion 54₂ in the color sub-pixel 24 is chosen to produce light in the wavelength range of 490nm to 570nm. In the embodiment where the third layer portion 54₃ in the color sub-pixel 26 is used to produce blue light in response to violet light, the size of the quantum dots in the third layer portion 54₃ is chosen to produce light in the wavelength range of 450nm to 480nm, for example.

In summary, according to various embodiments of the present invention, one luminescent layer is used to produce a shorter-wavelength light component. This shorter-wavelength light component is used to excite two or three excitable materials to produce two or three longer-wavelength light components. Thus, the light emitting diode according to the present invention may comprise: a first electrode layer; a second electrode layer; an organic layer disposed between the first and second electrode layers arranged to emit light in a first wavelength through the second electrode layer; a light re-emitting layer adjacent to the second electrode layer arranged to receive at least part of the light in the first wavelength, the light re-emitting layer comprising a first excitable material arranged to emit light in a second wavelength longer than the first wavelength in response to the light in the first wavelength; and a second excitable material arranged to emit light in a third wavelength longer than the second wavelength in response to the light in the first wavelength. The light in first wavelength is blue light in the wavelength range of 450nm to 480nm; the light in the second wavelength is green light in the wavelength range of 490nm to 570nm; and the light in the third wavelength is red light in the wavelength range of 590nm to 650nm. In another embodiment of the present invention, the light in the first wavelength is blue-greenish light in the wavelength of 460nm to 520nm.

In a different embodiment of the present invention, the light re-emitting layer further comprises a third excitable material arranged to emit light in a fourth wavelength longer than the first wavelength but shorter than the second wavelength. The light in first wavelength is violet light in the wavelength range of 380nm to 450nm; the light in the second wavelength is green light in the wavelength range of 490nm to 570nm; the light in the third wavelength is red light in the wavelength range of 590nm to 650nm; and the light in the fourth wavelength is blue light in the wavelength range of 410nm to 480nm or 450nm to 480nm.

The present invention has been described as an OLED arranged to produce light components in R, G, B from a light source in B, or to produce light components in R, G, B by excitation of a light source in violet. It is understood that the light components produced in an OLED may have two different colors such as R, G light components re-emitted upon being excited by a light source in B. Furthermore, Figures 2, 3A and 3B are for illustration purposes only. It is possible to rearrange the color sub-pixels 22, 24, 26 in a different order such as 22, 26, 24. Moreover, the three color sub-pixels 22, 24, 26 are not necessarily arranged in a single row.

Thus, although the present invention has been described with respect to one or more embodiments thereof, it will be understood by those skilled in the art that the foregoing and various other changes, omissions and deviations in the form and detail thereof may be made without departing from the scope of this invention.

What is claimed is:

1. A light emitting diode, comprising:

a first electrode layer;

5 a second electrode layer;

an organic layer disposed between the first and second electrode layers arranged to emit a first light component in a first wavelength through the second electrode layer;

a light re-emitting layer adjacent to the second electrode layer, arranged to receive at least part of the first light component, the light re-emitting layer comprising a first excitable material arranged
10 to emit a second light component in a second wavelength longer than the first wavelength in response to the first light component, and a second excitable material arranged to emit a third light component in a third wavelength longer than the second wavelength in response to the first light component.

2. The light emitting diode according to claim 1, wherein the light re-emitting layer further
15 comprises a third material arranged to transmit at least part of the first light component.

3. The light emitting diode according to claim 1, wherein the first wavelength is in a wavelength range of 450nm to 480nm, the second wavelength is in a wavelength range of 490nm to 570nm, and the third wavelength is in a wavelength range of 590nm to 650nm.
20

4. The light emitting diode according to claim 1, wherein the first wavelength is in a wavelength range of 460nm to 520nm, the second wavelength is in a wavelength range of 490nm to 570nm, and the third wavelength is in a wavelength range of 590nm to 650nm.

25 5. The light emitting diode according to claim 1, wherein the light re-emitting layer further comprises a third material arranged to provide a fourth light component in a fourth wavelength longer than the first wavelength but shorter than the second wavelength.

6. The light emitting diode according to claim 5, wherein the first wavelength is in a wavelength
30 range of 380nm to 480nm; the second wavelength is in a wavelength range of 490nm to 570nm; the

third wavelength is in a wavelength range of 590nm to 650nm, and the fourth wavelength is in a wavelength range of 410nm to 480nm.

7. The light emitting diode according to claim 1, further comprising:

5 a first barrier and a second barrier arranged to partition the light emitting diode into a first diode section, a second diode section and a third diode section, the first barrier arranged to separate the first excitable material from the second excitable material in the light re-emitting layer such that the first excitable material is located in a first diode portion and the second excitable material is located in the second diode section; the second barrier arranged to separate the first excitable material
10 from the third diode section; the first and second barriers also arranged to partition the first electrode layer into a first electrode section in the first diode section, a second electrode section in the second diode section and a third electrode section in the third diode section; and

a first switching element connected to the first electrode section, a second switching element connected to the second electrode section and a third switching element connected to the third
15 electrode section.

8. The light emitting diode according to claim 5, wherein the third material comprises a color filter.

20 9. A display panel, comprising:

a substrate;

a plurality of pixels formed on the substrate, each pixel comprising a light-emitting diode, the light-emitting diode comprising:

a first electrode layer;

25 a second electrode layer;

an organic layer disposed between the first and second electrode layers arranged to emit a first light component in a first wavelength through the second electrode layer;

a light re-emitting layer adjacent to the second electrode layer, arranged to receive at least part of the first light component, the light re-emitting layer comprising a first excitable material arranged
30 to emit a second light component in a second wavelength longer than the first wavelength in response

to the first light component, and a second excitable material arranged to emit a third light component in a third wavelength longer than the second wavelength in response to the first light component.

10. The display panel according to claim 9, further comprising:

5 a first barrier and a second barrier arranged to partition the light emitting diode into a first diode section, a second diode section and a third diode section, the first barrier arranged to separate the first excitable material from the second excitable material in the light re-emitting layer such that the first excitable material is located in a first diode portion and the second excitable material is located in the second diode section; the second barrier arranged to separate the first excitable material
10 from the third diode section; the first and second barriers also arranged to partition the first electrode layer into a first electrode section in the first diode section, a second electrode section in the second diode section and a third electrode section in the third diode section; and

a first switching element connected to the first electrode section, a second switching element connected to the second electrode section and a third switching element connected to the third
15 electrode section.

11. The display panel according to claim 10, further comprising a color filter located in the third diode section, the color filter arranged to transmit at least part of the first light component.

20 12. A method for producing a light emitting diode, comprising:

providing a first electrode layer and a second electrode layer on a substrate;

disposing an organic layer between the first and second electrode layers, the organic layer arranged to emit a first light component in a first wavelength through the second electrode layer;

25 disposing a light re-emitting layer adjacent to the second electrode layer, the light re-emitting layer arranged to receive at least part of the first light component, the light re-emitting layer comprising a first excitable material arranged to emit a second light component in a second wavelength longer than the first wavelength in response to the first light component, and a second excitable material arranged to emit a third light component in a third wavelength longer than the second wavelength in response to the first light component.

30 13. The method according to claim 12, further comprising:

providing a first barrier and a second barrier arranged to partition the light emitting diode into a first diode section, a second diode section and a third diode section, the first barrier arranged to separate the first excitable material from the second excitable material in the light re-emitting layer such that the first excitable material is located in a first diode portion and the second excitable material is located in the second diode section; the second barrier arranged to separate the first excitable material from the third diode section; the first and second barriers also arranged to partition the first electrode layer into a first electrode section in the first diode section, a second electrode section in the second diode section and a third electrode section in the third diode section; and

providing a first switching element connected to the first electrode section, a second switching element connected to the second electrode section and a third switching element connected to the third electrode section.

14. The method according to claim 13, further comprising

providing a color filter in the third diode section, the color filter configured to transmit at least part of the first light component.

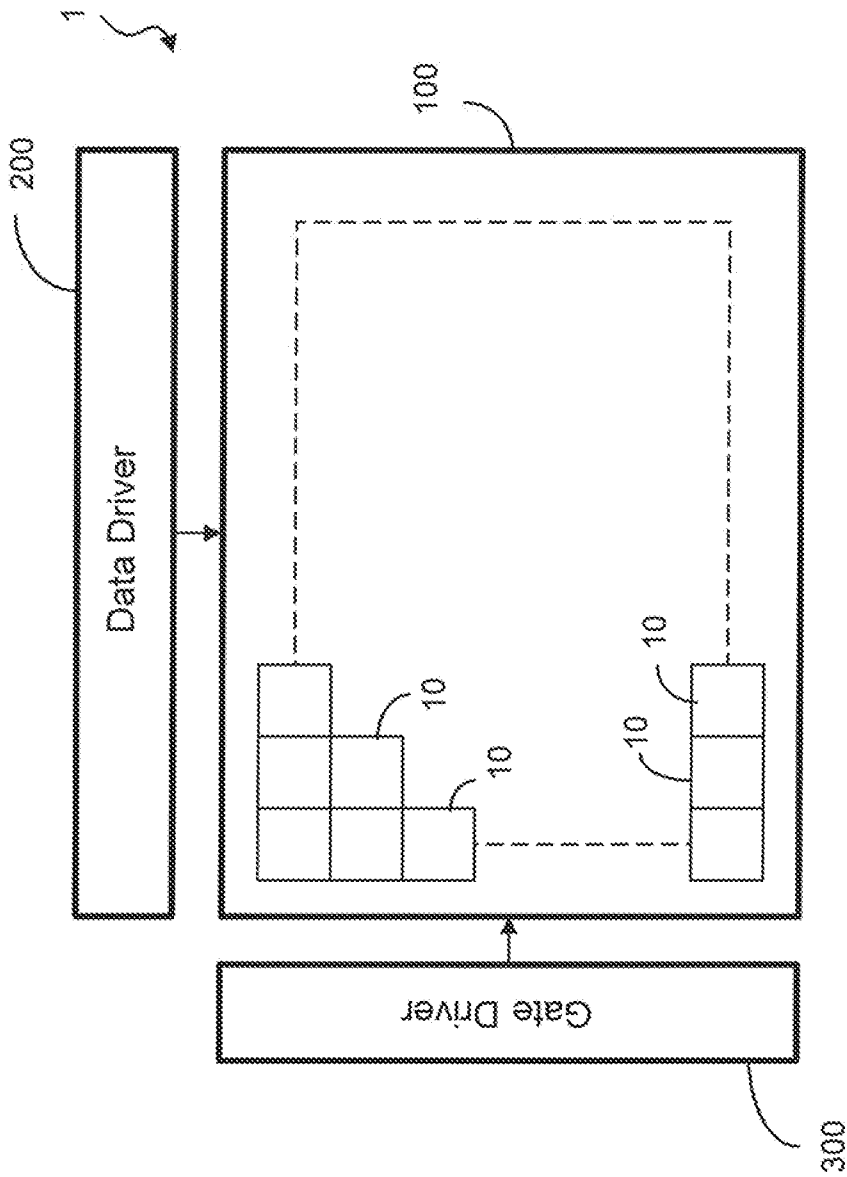


FIG. 1 (prior art)

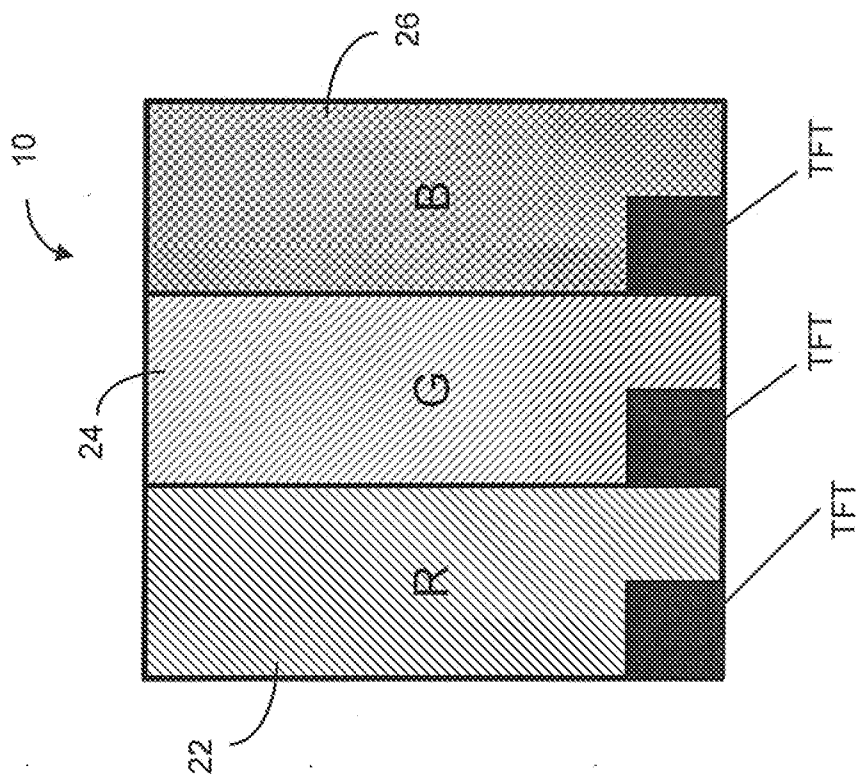


FIG. 2

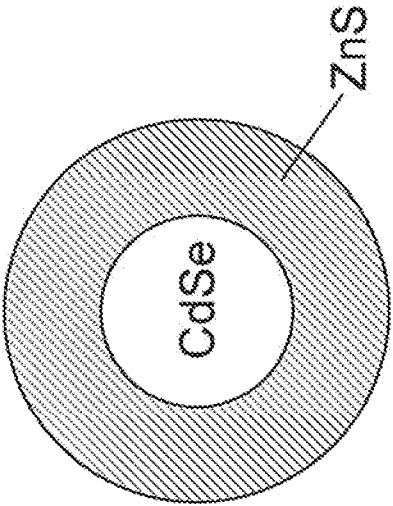
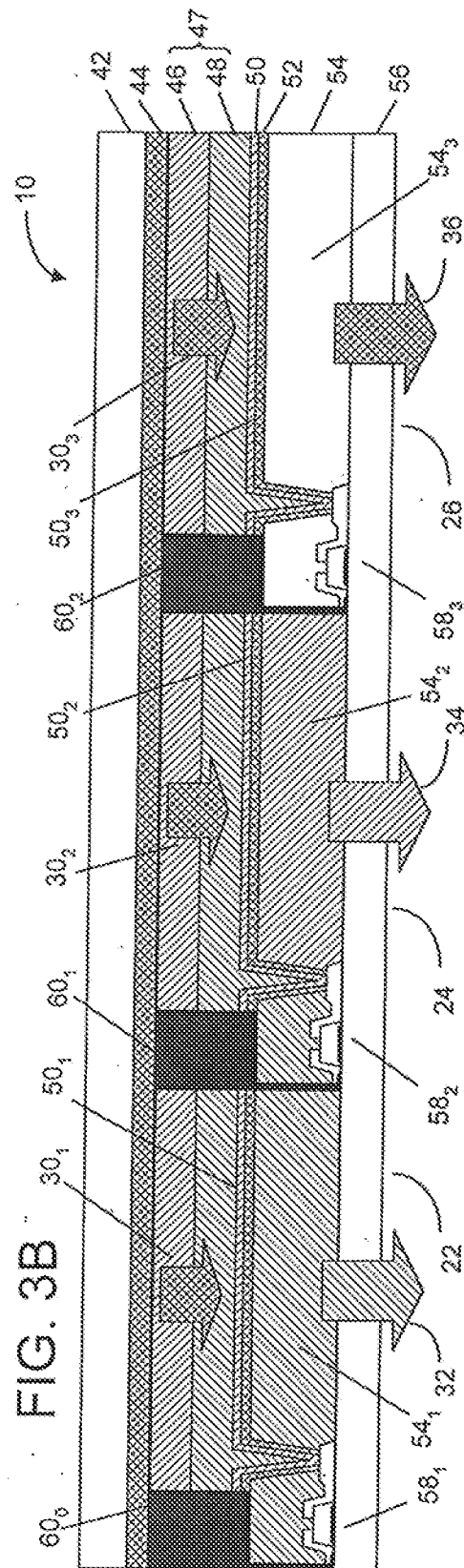
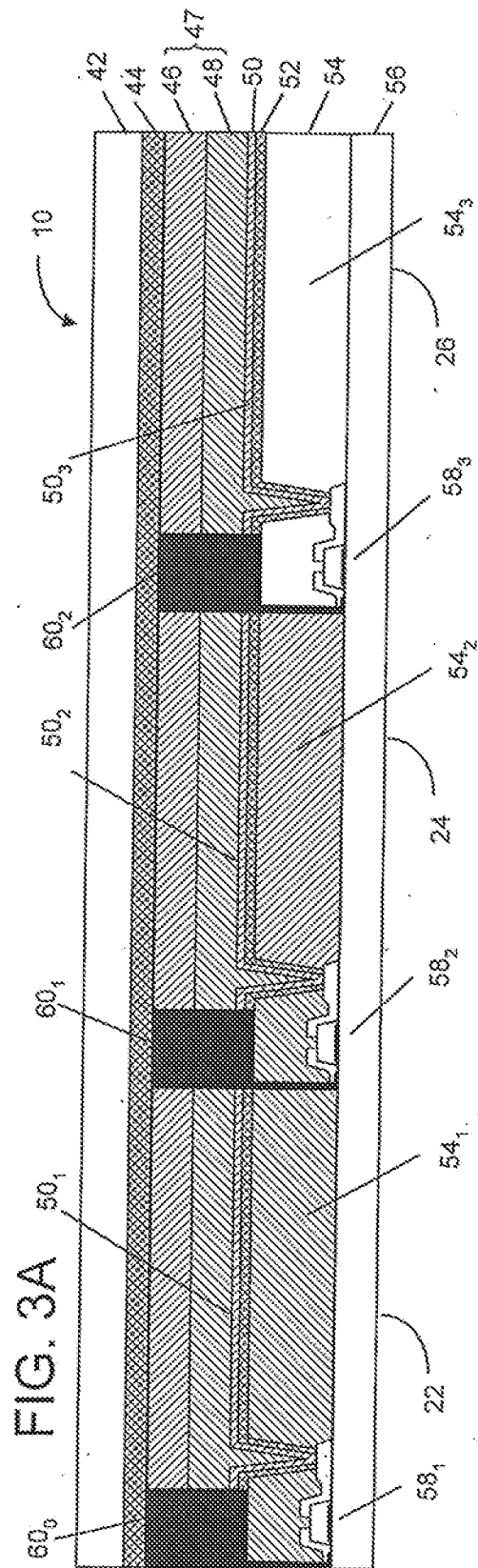


FIG. 5



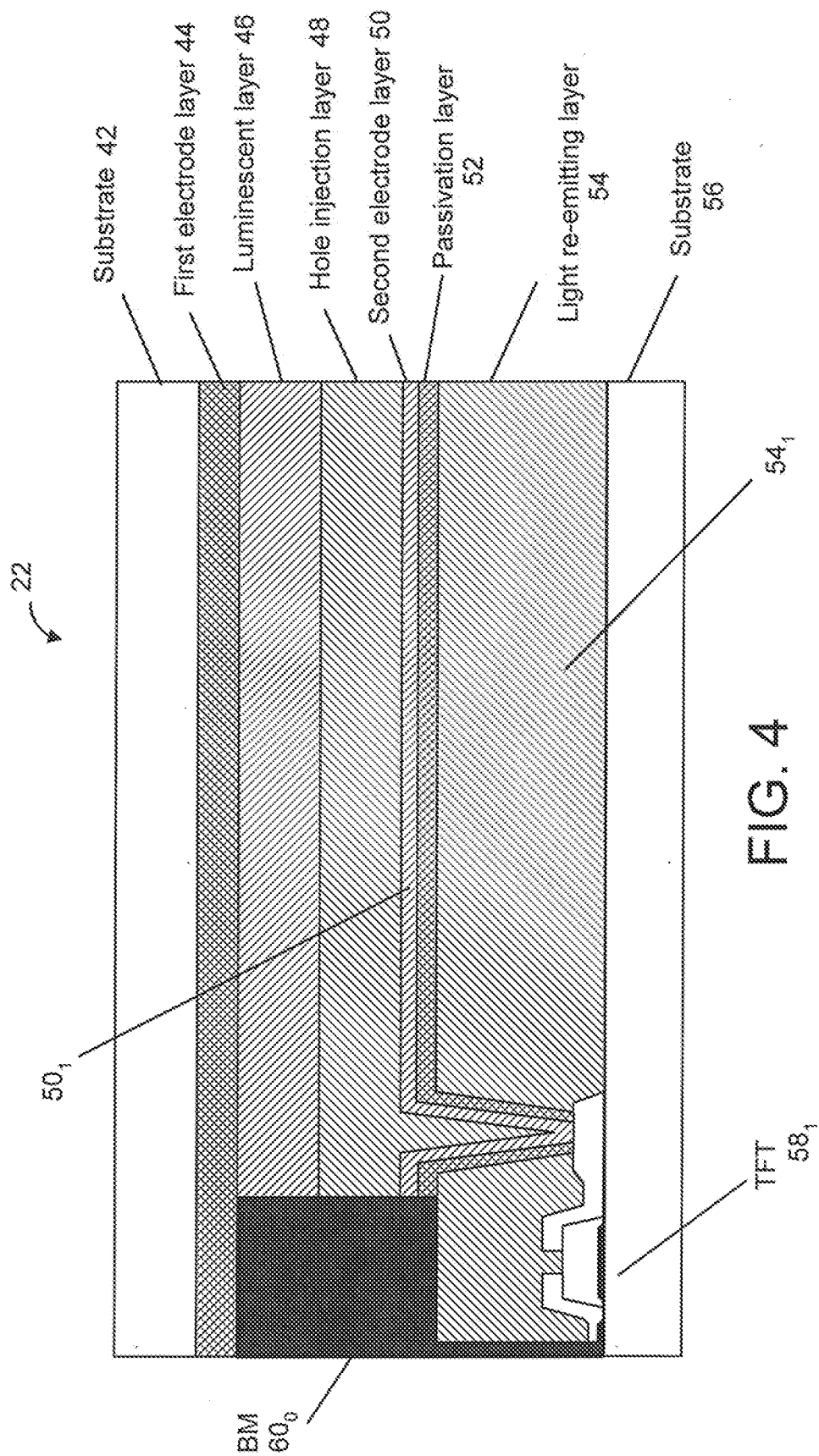


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/086108

A. CLASSIFICATION OF SUBJECT MATTER

See the extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H01L, H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNABS, CNKI, WPI, EPODOC: electrode, organic, light, emit+, diode, LCD, display, substrate?, panel, excit+, stimulat+, photolumine+, OLED, EL, R, G, B, red, green, blue

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 1685770 A (KONINKL PHILIPS ELECTRONICS NV) 19 October 2005 (19.10.2005) description, page 6, line 26 to page 8 line 13, figures 1-3	1-14
A	CN 101207075 A (LG PHILIPS LCD CO., LTD.) 25 June 2008 (25.06.2008) the whole document	1-14

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
“A” document defining the general state of the art which is not considered to be of particular relevance	“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
“E” earlier application or patent but published on or after the international filing date	“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
“L” document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)	“&” document member of the same patent family
“O” document referring to an oral disclosure, use, exhibition or other means	
“P” document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 13 December 2013 (13.12.2013)	Date of mailing of the international search report 23 Jan. 2014 (23.01.2014)
--	--

Name and mailing address of the ISA/CN
The State Intellectual Property Office, the P.R.China
6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China
100088
Facsimile No. 86-10-62019451

Authorized officer
CHEN, Jiajia
Telephone No. (86-10)61648430

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2013/086108

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 1685770 A	19.10.2005	WO 2004032576 A1	15.04.2004
		AU 2003260885 A1	23.04.2004
		EP 1550356 A1	06.07.2005
		JP 2006501617 A	12.01.2006
		KR 20050072424 A	11.07.2005
		US 2006152150 A1	13.07.2006
		CN 1685770 B	08.12.2010
CN 101207075 A	25.06.2008	US 2008150418 A1	26.06.2008
		DE 102007029915 A1	03.07.2008
		KR 20080058141 A	25.06.2008
		TW 200829075 A	01.07.2008
		US 7833569 B2	16.11.2010
		CN 101207075 B	08.12.2010
		TW I357776 B	01.02.2012
		US 2011057561 A1	10.03.2011
		US 8344615 B2	01.01.2013

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/086108

A. CLASSIFICATION OF SUBJECT MATTER

H01L 27/32 (2006.01)i

H01L 51/50 (2006.01)i

H01L 51/54 (2006.01)i

H05B 33/14 (2006.01)i