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(71) Applicant: **Samsung Mobile Display Co., Ltd.**
Yongin-city, Gyunggi-do 446-711 (KR)

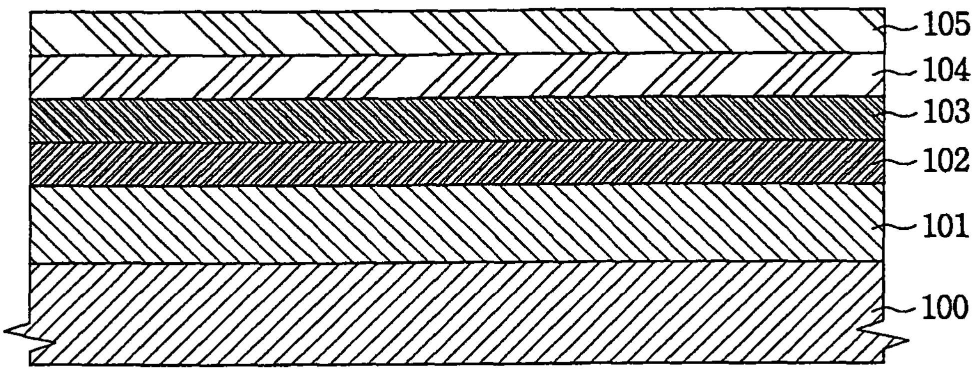
(72) Inventors:
- **Jun, Hyuk-Sang**
  Yongin-City,
  Gyunggi-Do 446-711 (KR)
- **Song, Ok Keun**
  Yongin-City,
  Gyunggi-Do 446-711 (KR)
- **Jeong, Hye-In**
  Yongin-City,
  Gyunggi-Do 446-711 (KR)
- **Young-Mo, Koo**
  Yongin-City,
  Gyunggi-Do 446-711 (KR)

(74) Representative: **Mounteney, Simon James**
Marks & Clerk LLP
90 Long Acre
London
WC2E 9RA (GB)

(54) Organic light emitting diode display device

(57) An organic light emitting diode display device which can improve brightness and color coordinate characteristics in all emission wavelength ranges, and thus can enhance light extraction efficiency and color reproducibility. The organic light emitting diode display device includes a substrate (100), a first electrode (103) disposed on the substrate, an organic layer disposed on the first electrode (103) and having an emission layer, a second electrode (105) disposed on the organic layer, and first (102) and second (101) refraction layers. A stack of the first (102) and second (101) refraction layers is disposed either between the first electrode (103) and the substrate (100) or on the second electrode. A refractive index of the first refraction layer is smaller than a refractive index of the second refraction layer. A thickness of the first refraction layer is no greater than 100 nm.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an organic light emitting diode (OLED) display device.

Description of the Related Art

[0002] Light efficiency for light emitting devices, particularly flat panel display devices such as OLED display devices, is classified into internal efficiency and external efficiency. The internal efficiency depends on photoelectric conversion efficiency of an organic light emitting material. In addition, the external efficiency, called light extraction efficiency, depends on a refractive index of each layer constituting an organic light emitting diode. The organic light emitting diode exhibits relatively lower light extraction efficiency, i.e., the external efficiency than other display devices such as cathode-ray tubes or PDPs, and thus there is much room for improvement in characteristics of the display device such as brightness, life span, etc.

[0003] The biggest reason that the conventional organic light emitting diode has a lower light extraction efficiency than other display devices is because total reflection occurs at an interface between an ITO electrode layer having a high refractive index and a substrate having a low refractive index when light is emitted through the organic layer at more than a critical angle, thus preventing extraction of the light. Therefore, due to the total internal reflection at the interface in the organic light emitting diode, only about a quarter of the light actually generated from an organic emission layer can be extracted outside.

[0004] An example of a conventional OLED display device for preventing a decrease in light extraction efficiency is disclosed in Japanese Patent Publication No. 63-314795. The OLED display device includes a substrate having a projecting lens. However, because a single pixel has a very small area, it is difficult to form the projecting lens for collecting light on the substrate.

[0005] To solve this problem of the OLED display device, an OLED display device having an optical microcavity is disclosed in Japanese Patent Application Laid-open Nos. 8-250786, 8-213174 and 10-177896. The OLED display device has a multi-layered semi-transparent mirror formed between a glass substrate and an ITO electrode, and the semi-transparent mirror serves as an optical resonator together with a metal cathode also serving as a reflective plate. Here, the semi-transparent mirror has a multi-layered structure by alternately stacking a TiO_2 layer having a high refractive index and a SiO_2 layer having a low refractive index, and an optical resonance is achieved by controlling reflections between the layers. However, such an optical resonator requires as many layers for the semi-transparent mirror as possible to improve refraction characteristics, and the number of layers and thickness of each of the layers have to be accurately optimized to control the reflection at a specific wavelength. For this reason, a process for fabricating the OLED display device may become complicated.

SUMMARY OF THE INVENTION

[0006] The present invention sets out to provide an organic light emitting diode (OLED) display device which can improve brightness and color coordinate characteristics in all emission wavelength ranges using a simple structure and process and thus enhance light extraction efficiency and color reproducibility.

[0007] According to an embodiment of the present invention, an OLED display device includes a substrate, a first electrode disposed on the substrate, an organic layer disposed on the first electrode and including an emission layer, a second electrode disposed on the organic layer, and a first and a second refraction layers. A stack of the first and second refraction layers is disposed either between the first electrode and the substrate or on the second electrode. A refractive index of the first refraction layer is smaller than a refractive index of the second refraction layer. A thickness of the first refraction layer is no greater than 100 nm.

[0008] The first electrode may be a transmissive electrode, and the second electrode may be a reflective electrode. In this case, the first refraction layer is disposed between the first electrode and the substrate, and the second refraction layer is disposed between the first refraction layer and the substrate.

[0009] The first electrode may be a reflective electrode, and the second electrode may be a transmissive electrode. In this case, the first refraction layer is disposed on the second electrode, and the second refraction layer is disposed on the first refraction layer.

[0010] The above and other features of the invention are set out in the appended claims.

[0011] According to another embodiment of the present invention, an OLED display device includes a substrate including a plurality of unit pixel regions, a plurality of organic light emitting diodes disposed on the unit pixel regions of the substrate, and a first and a second refraction layers. Each of the organic light emitting diodes includes a first electrode, a second electrode, and an organic layer disposed between the first and the second electrodes. The organic layer has an emission layer. A stack of the first and second refraction layers is disposed either between the first electrode of each of the organic light emitting diodes and the substrate or on the second electrode of each of the organic light emitting diodes. A refractive index of the first refraction layer is smaller than a refractive index of the second refraction layer. A thickness of the first refraction layer is no greater than 100 nm.

[0012] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] A more complete appreciation of the invention, and many of the attendant advantages thereof, will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings in which like reference symbols indicate the same or similar components, wherein:

[0014] FIG. 1 is a cross-sectional view of an organic light emitting diode (OLED) display device according to a first embodiment of the present invention;

[0015] FIG. 2 is a cross-sectional view of an OLED display device according to a second embodiment of the present invention;

[0016] FIG. 3 is a cross-sectional view of an OLED display device according to a third embodiment of the present invention; and

[0017] FIG. 4 is a cross-sectional view of an OLED display device according to a fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Reference will now be made in detail to the present embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

[0019] FIG. 1 is a cross-sectional view of an organic light emitting diode (OLED) display device according to a first embodiment of the present invention. In the present embodiment, the OLED display device is a bottom-emitting OLED display device which emits light toward a substrate.

[0020] Referring to FIG. 1, a substrate 100, a second refraction layer 101, and a first refraction layer 102 are sequentially disposed, and an organic light emitting diode including a first electrode 103, an organic layer 104 having an emission layer, and a second electrode 105 are disposed on the first refraction layer 102. A sealing member (not illustrated) may be further included over the second electrode 105.

[0021] The substrate 100 is formed of a light-penetrating material. The substrate 100 may be formed of transparent glass, or transparent polymer material, e.g., polymethylmethacrylate (PMMA), polyaniline (PANI) or polyethylene terephthalate (PET).

[0022] An amount of light emitted from the emission layer of the organic layer 104 is reflected at surfaces of the second refraction layer 101, the first refraction layer 102, and the second electrode 105. Reflection between surfaces of these layers induces optical resonance. Due to the optical resonance, the intensity of the light generated from the emission layer is amplified through the optical resonance. The amplified light transmits out of the display device, and thus light extraction efficiency improves.

[0023] In the present embodiment, a refractive index n1 of the first refraction layer 102 is smaller than a refractive index n2 of the second refraction layer 101.

The first refraction layer 102 is formed not exceeding 100 nm. If the thickness of the first refraction layer 102 is greater than 100 nm, there is almost no significant difference in light extraction efficiency and color reproducibility according to the change in thickness of the first refraction layer 102. Moreover, if the first refraction layer 102 is thicker, it absorbs the light emitted from the emission layer, which can have an adverse effect on light extraction. Accordingly, the first refraction layer 102 is preferably formed not exceeding 100 nm. The first refractive layer 102 also protects the second refraction layer 101 disposed under the first refractive layer 102 during patterning of the first electrode 103.

[0024] When the thickness of the first refraction layer 102 is 100 nm or less, the second refraction layer 101 may be formed to a thickness not exceeding 350 nm. When the second refraction layer 101 has a thickness greater than 350 nm, the absorption of light in the second refraction layer 101 may increase. Preferably, the second refraction layer 101 may be formed to a thickness of 20 nm to 100 nm, or 150 nm to 350 nm, and more particularly, 50 nm to 80 nm or 180 nm to 200 nm. In this range, the light extraction efficiency and the color reproducibility can be significantly increased as compared with other thickness ranges. In wavelengths ranging from about 400 nm to 800 nm, which includes wavelengths for red, green and blue colors, the light extraction efficiency and the color reproducibility increase even when the first and second refraction layers 102 and 101 are formed to have the same thickness.

[0025] The first and second refraction layers 102 and 101 are formed of a transparent material. Specifically, the first and second refraction layers 102 and 101 may be formed of niobium oxide (Nb_2O_5 tantalum oxide (Ta_2O_5), titanium oxide (Ti_2O_5) silicon nitride (SixNy), silicon oxide (SiO_2), antimony oxide (Sb_2O_3), aluminum oxide (Al_2O_3), zirconium oxide (ZrO_2), magnesium oxide (MgO), hafnium dioxide (HfO_2) or synthetic polymer. The materials are selectively mixed to make the refractive index n1 of the first refraction layer 102 smaller than the refractive index n2 of the second refraction layer 101. Here, the materials for the first and second refraction layers 102 and 101 can be selected to have n1 ranging from 1.4 to less than 1.8 and to have n2 be 1.1 times of n1. In addition, n1 may be less than a refractive index of the first electrode 103.

[0026] The first and second refraction layers 102 and 101 may be formed by a sol-gel, spin coating, spraying, roll coating, ion beam deposition, electron beam deposition, laser ablation, chemical vapor deposition (CVD) or sputtering method, and preferably by a sputtering method to ensure uniformity and stability in forming a large-sized layer.

[0027] Meanwhile, a third refraction layer, which is the same layer as the first refraction layer 102, may be further disposed between the second refraction layer 101 and the substrate 100. Alternatively, a stacked structure of the first and second refraction layers 102 and 101 or a stacked structure of the first refraction layer 102, the second refraction layer 101 and the third refraction layer may be repeatedly formed.

[0028] Subsequently, the first electrode 103 is disposed on the first refractive layer 102, and serves as a transmissive electrode, through which light is emitted. The first electrode 103 may function as an anode, and may be formed of indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (TO), zinc oxide (ZnO) or a transparent conductive material. Alternatively, the first electrode 103 may function as a cathode, and may be formed as a thin layer through which light can pass. For example, the first electrode 103 can be made of a material such as conductive metals having a low work function, e.g., magnesium (Mg), calcium (Ca), aluminum (Al), silver (Ag) or an alloy thereof.

[0029] The organic layer 104 includes an emission layer, and may further include at least one layer selected from: a hole injection layer, a hole transport layer, an electrode injection layer, an electrode transport layer, a hole blocking layer and an electron blocking layer.

[0030] The material for forming the emission layer is not particularly limited, and it may be formed of any material selected from well-known host and dopant materials.

[0031] The host material includes 4,4'-N,N'-dicarbazole-biphenyl (CBP), bis-(2-methyl-8-quinolinato)-4-phenylphenolate aluminum (BAlq), 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), N,N'-dicarbazolyl-1,4-dimethene-benzene (DCB), rubrene, and 9,10-bis(2-naphthyl)antracene (AND). The dopant material includes 4,4'-bis(2,2'-diphenylvinyl)-1,1'-biphenyl (DPVBi), distyrylamine derivatives, pyrene derivatives, perylene derivatives, distyrylbiphenyl (DSBP) derivatives, 10-(1,3-benzothiazole-2-yl)-1,1,7,7-tetramethyl-2,3,6,7-tetrahydro-1H,5H,11H-pyrano(2,3-f)pyrido(3,2,1-ij) quinoline-11-one (C545T), quinacridone derivatives, tris(2-phenylpyridine)iridium ($Ir(PPy)_3$), PQIr, $Btp_2Ir(acac)$, 4-(dicyanomethlylene)-2-tert-buthyl-6-(1,1,7,7-tetramethyljulorydyl-9-enyl)-4H-pyrane (DCJTB), 4-(dicyanomethylene)-2-methyl-6-(p-dimethylaminostyryl)-4H-pyrane (DCM), 2,3,7,8,12,13,17,18-oxtaethyl-21 H,23H-porphirne-platinum complex (PtOEP), $Ir(piq)_2(acac)$, RD3(Kodak) and EK8(Kodak).

[0032] The hole injection layer may be formed of 4,4',4"-tris(3-methylphenylamino)triphenylamino (m-MTDATA), 1,3,5-trus[4-(3-methylphenylamino)phenyl]benzene (m-MTDATB), copper phthalocyanine (CuPc) or N,N'-di(4-(N,N'-diphenylamino)phenyl)-N,N'-diphenylbenzine (DNTPD), and the hole transport layer may be formed of N,N'-diphenyl-N,N'-bis (3-methylphenyl)-1,1'-biphenyl-4,4'-diamine (TPD), N,N'-di(naphthalene-1-yl)-N,N'-diphenyl benzidine (α-NPD), or 4,4'-bis(1-naphthylphenylamino)biphenyl (NPB).

[0033] The electron blocking layer may be formed of BAlq, BCP, CF-X, 3-(4-t-butylphenyl)-4-phenyl-5-(4-biphenyl)-1,2,4-triazole (TAZ) or spiro-TAZ, and the hole blocking layer 160 may be formed of 2-(4-biphenyl)-5-(4-tert-butylphenyl)-1,3,4-oxydiazole (PBD), spiro-PBD or TAZ.

[0034] The electron transport layer may be formed of TAZ, PBD, spiro-PBD, Alq_3, BAlq or SAlq, and the electron injection layer may be formed of LiF, a Ga complex, Liq or CsF.

[0035] The organic layer 104 may be formed by thermal vacuum deposition, vapor deposition, spin coating, dip coating, doctor blading, inkjet printing or laser induced thermal imaging.

[0036] The second electrode 105 is formed as a reflective layer. The second electrode 105 may function as a cathode, and may be formed as a thick layer to reflect light. The second electrode 105 may be formed of one material selected from the group consisting of conductive metals having a low work function, e.g., Mg, Ca, Al, Ag and an alloy thereof. Alternatively, the second electrode 105 may function as an anode, and may have a stacked structure having a reflective layer, which is formed of Ag, Al, chromium (Cr), Molybdenum (Mo), tungsten (W), titanium (Ti), gold (Au), palladium (Pd) or an alloy thereof, and a transparent layer, which is formed of ITO, IZO, TO or ZnO on the reflective layer.

[0037] FIG. 2 is a cross-sectional view of an OLED display device according to a second embodiment of the present invention. The OLED display device is a top-emitting device, unlike the first embodiment. Except particular descriptions below, descriptions of the display device of the second embodiment will refer to those of the first embodiment.

[0038] Referring to FIG. 2, a first electrode 201 is disposed on a substrate 200. The first electrode 201 is formed as a reflective electrode. An organic layer 202 having an emission layer is disposed on the first electrode 201. A second electrode 203 is disposed on the organic layer 202. The second electrode 203 is formed as a transmissive electrode.

[0039] In the present embodiment, since light is emitted through the second electrode 203, a first refraction layer 204 is disposed on the second electrode 203, and a second refraction layer 205 is disposed on the first refraction layer 204. Like the first embodiment, a refractive index n1 of the first refraction layer 204 is smaller than a refractive index n2 of the second refraction layer 205, and the first refraction layer 204 is formed to a thickness not exceeding 100 nm. Meanwhile, the second refraction layer 205 may be formed to a thickness not exceeding 350 nm, preferably 20 nm to 100 nm or 150 nm to 350 nm, and more preferably 50 nm to 80 nm or 180 nm to 200 nm.

[0040] FIG. 3 is a cross-sectional view of an OLED display device according to a third embodiment of the present invention. The OLED display device is an active matrix OLED display device including a thin film transistor electrically connected to a first electrode formed on a substrate, and is a bottom-emitting device. Except particular descriptions below, descriptions of the OLED display device of the third embodiment will refer to those of the first and second embodiments.

[0041] Referring to FIG. 3, a thin film transistor 306 including a semiconductor layer 301, a gate insulating layer 302, a gate electrode 303, and source and drain electrodes 304 and 305 is disposed on a substrate 300. A passivation layer 307 may be disposed on the source and drain electrodes 304 and 305.

[0042] A second refraction layer 308 is disposed on the passivation layer 307, and a first refraction layer 309 is disposed on the second refraction layer 308.

[0043] A first electrode 310 is disposed on the first refraction layer 309, and electrically connected to one of the source and drain electrodes 304 and 305 of the thin film transistor 306. The first electrode 310 is formed as a transmissive electrode.

[0044] An organic layer 311 having an emission layer is disposed on the first electrode 310, and a second electrode 312 is disposed on the organic layer 311. The second electrode 312 is formed as a reflective electrode.

[0045] Meanwhile, in the top-emitting active-matrix OLED display device, the first electrode 310 is formed as a reflective electrode, and the second electrode 312 is formed as a transmissive electrode. The first refraction layer 309 is disposed over the second electrode 312, and the second refraction layer 308 is disposed on the first refraction layer 309. Alternatively, the first and second refraction layers 309 and the 308 may be disposed between the gate insulating layer 302 and the substrate 300.

[0046] FIG. 4 is a cross-sectional view of an OLED display device according to a fourth embodiment of the present invention. The OLED display device is a full-color OLED display device having red, green and blue pixels, and is a bottom-emitting type. Except particular descriptions below, descriptions of the OLED display device will refer to those of the above embodiments.

[0047] Referring to FIG. 4, a substrate 400 having red (R), green (G) and blue (B) unit pixel regions is disposed. A second refraction layer 401 is disposed on the substrate 400, and a first refraction layer 402 is disposed on the second refraction layer 401. Like the above embodiments, a refractive index n1 of the first refraction layer 402 is lower than a refractive index n2 of the second refraction layer 401, and the first refraction layer 402 is formed to a thickness greater than 0 and not exceeding 100 nm. Meanwhile, the second refraction layer 401 may be formed to a thickness greater than 0 and not exceeding 350 nm, preferably, 20 nm to 100 nm or 150 nm to 350 nm, and more preferably 50 nm to 80 nm or 180 nm to 200 nm. In this range, light extraction efficiency and color reproducibility can be significantly increased as compared with other thickness ranges, and can also be increased even when the first and second refraction layers 402 and 401 have the same thickness in a wavelength range of red, green and blue light, which is a wavelength ranging from about 400 to 800nm. Therefore, the first and second refraction layers 402 and 401 do not need to be separately formed in each pixel, and thus the fabrication process can be simple.

[0048] First electrodes 403R, 403G and 403B are disposed in respective unit pixel regions on the first refraction layer 402. The first electrodes 403R, 403G and 403B are transmissive electrodes. An insulating layer 404 defining pixel regions is disposed between the first electrodes 403R, 403G and 403B.

[0049] Organic layers 405R, 405G and 405B having red, green and blue emission layers, respectively, are disposed on the first electrodes 403R, 403G and 403B, respectively. The organic layers 405R, 405G and 405B may be formed by vacuum deposition using a fine pitch mask, inkjet printing or laser induced thermal imaging. The organic layers 405R, 405G and 405B may be formed to the same thickness. However, to maximize resonance effect, the organic layer in a unit pixel region emitting light having a longer wavelength is preferably thicker than the organic layer in a unit pixel region emitting light having a shorter wavelength.

[0050] Separators 406 may be disposed on the insulating layer 404. Second electrodes 407, each of which is isolated by the separators 406, are disposed on the organic layers 405R, 405G and 405B. The second electrodes 407 are reflective electrodes.

[0051] Meanwhile, in the top-emission active-matrix OLED display device, the first electrodes 403R, 403G and 403B are formed as reflective electrodes, and the second electrodes 407 are formed as transmissive electrodes. In addition, the first refraction layer 402 is disposed over the second electrode 407, and the second refraction layer 401 is disposed on the first refraction layer 402.

[0052] Moreover, red, green and blue color filters 408R, 408G and 408B may be disposed in the respective unit pixel regions between the substrate 400 and the second refraction layer 401. The color filters 408R, 408G and 408B can further enhance color purity. A black matrix 409 may be disposed between the color filters.

[0053] Hereinafter, preferable experimental examples will be described to aid in understanding of the present invention. However, it should be understood that the experimental examples described below are provided to aid in understanding of the present invention, and not to limit the present invention.

[0054] Experimental examples 1 to 4

[0055] Sample OLED display devices were fabricated. Second refraction layers (Nb_2O_5, refractive index: 2.4) were formed to thicknesses listed in Table 1 on respective glass substrates. A first refraction layer (SiO_2, refractive index: 1.45) was formed to a thickness of 30 nm on the second refraction layer. A first electrode, which was made of ITO, was formed to a thickness of 50 nm on the first refraction layer. A hole injection layer was formed to a thickness of 75 nm using DNTPD on the first electrode, and a hole transport layer was formed to a thickness of 15 nm using NPB on the hole injection layer. A blue emission layer was formed to a thickness of 25 nm using AND as a host and EK8 (Kodak) as a dopant on the hole transport layer. Subsequently, an electron transport layer was formed to a thickness of 25 nm using Alq_3 on the blue emission layer, and an electron injection layer was formed to a thickness of 5 nm using LiF on the electron transport layer. A second electrode was formed to a thickness of 80 nm using Al on the electron injection layer.

[0056] Experimental examples 5 to 8

[0057] Except that a first refraction layer was formed to a thickness of 90 nm, other sample OLED display devices were fabricated with the same conditions as in Experimental examples 1 to 4.

[0058] Comparative example 1

[0059] Compared with Experimental example 1, first and second refraction layers were not formed.

[0060] Comparative examples 2 to 5

[0061] Except that a first refraction layer was formed to a thickness of 120 nm, the samples were fabricated with the same conditions as in Experimental examples 1 to 4.

[0062] Tables 1 and 2 show color coordinates and brightness of the OLED display devices fabricated for Experimental examples 1 to 4 and 5 to 8. Tables 3 and 4 show color coordinates and brightness of the OLED display devices fabricated for Comparative examples 1 and 2 to 5.

[0063]

Table 1

	Thickness of Nb_2O_5 (nm)	X	y	Brightness
E. example 1	50	0.149	0.093	62.7
E. example 2	80	0.134	0.140	89.7
E. example 3	180	0.134	0.145	82.3
E. example 4	230	0.154	0.131	86.6

[0064]

Table 2

	Thickness of Nb_2O_5 (nm)	X	y	Brightness
E. example 5	50	0.124	0.141	96.5
E. example 6	80	0.125	0.209	120.2
E. example 7	180	0.127	0.179	111.1
E. example 8	230	0.137	0.142	96.6

[0065]

Table 3

	x	Y	Brightness
C. example 1	0.145	0.202	112.5

[0066]

Table 4

	Thickness of Nb_2O_5 (nm)	X	y	Brightness
C. example 2	50	0.141	0.403	153.4
C. example 3	80	0.165	0.268	130.9
C. example 4	180	0.137	0.263	137.6
C. example 5	230	0.140	0.344	134.8

[0067] Referring to Tables 1 to 4, in Experimental examples 1 to 4 and 5 to 8, comparing the first refraction layers having thicknesses of 30 nm and 90 nm, the brightness was slightly decreased at 30 nm, but the y value of the color coordinates was significantly decreased compared to Comparative example 1, or there was no significant difference in y value and the brightness was increased. For blue, although the brightness was slightly decreased, the color reproducibility was increased as the y value is decreased. Therefore, when the first refraction layer was formed to a thickness of 100 nm or less, the color reproducibility and the light extraction efficiency were increased. On the other hand, in Comparative examples 2 to 5, when the second refraction layer was formed to a thickness of 120 nm, the brightness was increased, but the y value of the color coordinates was significantly increased compared to Comparative example 1. Thus, the increase in y value has a bad influence on the color reproducibility in spite of the increase in brightness.

[0068] Experimental examples 9 to 20

[0069] Second refraction layers (Nb_2O_5, refractive index: 2.4) were formed to thicknesses listed in Table 5 on respective glass substrates. A first refraction layer (SiO_2, refractive index: 1.45) was formed to a thickness of 30 nm on the second refraction layer. The first electrode was formed to a thickness of 50 nm using ITO on the first refraction layer. Hole injection layers were formed to thicknesses of 145, 100 and 75 nm for red, green and blue pixels using DNTPD on the first electrode, respectively. A hole transport layer was formed to a thickness of 15 nm using NPB on the hole injection layers. A red emission layer was formed to a thickness of 45 nm using rubrene as a host and RD3 (Kodak) as a dopant, a green emission layer was formed to a thickness of 45 nm using Alq_3 as a host and C545T as a dopant, and a blue emission layer was formed to a thickness of 25 nm using AND as a host and EK8 (Kodak) as a dopant on the hole transport layer. Subsequently, an electron transport layer was formed to a thickness of 25 nm using Alq_3 on the emission layers, and an electron injection layer was formed to a thickness of 5nm using LiF on the electron transport layer. A second electrode was formed to a thickness of 80nm using Al on the electron injection layer.

[0070] Experimental examples 21 to 32

[0071] Except that Ta_2O_5 having a refractive index of 2.1 as a second refraction layer was used, the experiments were performed under the same conditions as in Experimental examples 9 to 20.

[0072] Experimental examples 33 to 44

[0073] Except that TiO_2 having a refractive index of 2.3 as a second refraction layer was used, the experiments were performed under the same conditions as in Experimental examples 9 to 20.

[0074] Experimental examples 45 to 50

[0075] Except that SiN having a refractive index of 1.8 as a second refraction layer was formed to a thickness listed in Table 8, the experiments were performed under the same conditions as in Experimental example 9.

[0076] Comparative example 6

[0077] Except that first and second refraction layers were not formed, the experiment was performed under the same conditions as in Experimental example 9.

[0078] Tables 5 to 8 show color coordinates and brightness for red, green and blue light in the OLED display devices according to Experimental examples 9 to 50. Table 9 shows color coordinates and brightness for red, green and blue light in the OLED display device according to Comparative example 6.

[0079]

Table 5

	Thickness of Nb_2O_5 (nm)	Red			Green			blue		
		x	y	Brightness	x	y	Brightness	x	y	Brightness
E.example 9	20	0.662	0.338	131.2	0.265	0.671	132.2	0.145	0.124	87.8
E.example 10	50	0.661	0.339	204.8	0.264	0.693	177.5	0.129	0.131	95.4
E.example 11	80	0.670	0.329	195.5	0.328	0.642	159.9	0.123	0.213	124.4
E.example 12	100	0.673	0.327	148.3	0.342	0.619	135.0	0.141	0.187	121.0
E.example 13	120	0.670	0.333	122.4	0.302	0.641	130.3	0.147	0.132	101.1
E.example 14	150	0.660	0.340	139.7	0.256	0.695	162.6	0.129	0.144	95.0
E.example 15	180	0.661	0.338	207.2	0.300	0.667	162.8	0.125	0.188	113.8
E.example 16	200	0.668	0.332	204.5	0.329	0.635	147.7	0.138	0.166	118.7
E.example 17	230	0.673	0.327	143.8	0.306	0.640	140.2	0.141	0.145	102.8
E.example 18	270	0.662	0.338	133.3	0.273	0.686	160.5	0.129	0.168	103.6
E.example 19	300	0.660	0.340	192.4	0.308	0.656	151.8	0.135	0.157	114.3
E.example 20	350	0.673	0.327	155.8	0.292	0.658	151.6	0.135	0.162	102.1

[0080]

Table 6

		Red			Green			blue		
	Thickness of Ta_2O_5 (nm)	x	y	Brightness	x	y	Brightness	x	y	Brightness
E.example 21	20	0.664	0.336	124.4	0.286	0.656	124.7	0.145	0.152	97.1
E.example 22	50	0.662	0.338	165.8	0.269	0.680	157.7	0.135	0.135	97.6
E.example 23	80	0.667	0.333	186.0	0.310	0.655	159.5	0.126	0.193	118.0
E.example 24	100	0.670	0.329	162.1	0.334	0.631	142.7	0.132	0.215	124.8
E.example 25	120	0.667	0.333	119.1	0.334	0.623	127.5	0.144	0.185	117.2
E.example 26	150	0.661	0.338	142.1	0.288	0.655	132.2	0.144	0.140	100.8
E.example 27	180	0.662	0.338	171.0	0.274	0.680	154.3	0.130	0.165	103.8
E.example 28	200	0.668	0.332	179.2	0.295	0.667	155.7	0.127	0.193	112.7
E.example 29	230	0.673	0.327	143.8	0.328	0.634	140.7	0.138	0.181	118.7
E.example 30	270	0.671	0.329	131.9	0.305	0.641	134.0	0.141	0.155	105.9
E.example 31	300	0.666	0.334	122.6	0.279	0.673	148.3	0.133	0.175	105.0
E.example 32	350	0.662	0.338	174.1	0.315	0.646	142.8	0.138	0.168	115.7

[0081]

Table 7

		Red			Green			blue		
	Thickness of TiO_2 (nm)	x	y	Brightness	x	y	Brightness	x	y	Brightness
E.example 33	20	0.662	0.338	129.2	0.270	0.667	130.4	0.145	0.129	90.0
E.example 34	50	0.661	0.339	193.8	0.264	0.691	173.6	0.130	0.131	95.9
E.example 35	80	0.669	0.330	195.9	0.324	0.646	160.7	0.123	0.210	123.0
E.example 36	100	0.673	0.327	153.2	0.342	0.621	137.1	0.139	0.194	122.9
E.example 37	120	0.671	0.329	125.0	0.313	0.633	128.2	0.147	0.141	105.6
E.example 38	150	0.662	0.338	130.4	0.259	0.688	155.8	0.133	0.142	94.3
E.example 39	180	0.660	0.340	188.9	0.291	0.672	163.2	0.124	0.187	111.1
E.example 40	200	0.666	0.334	205.3	0.322	0.644	150.9	0.135	0.174	118.8
E.example 41	230	0.673	0.327	155.9	0.319	0.630	137.1	0.142	0.149	107.9
E.example 42	270	0.666	0.334	124.9	0.272	0.683	156.9	0.130	0.167	102.0
E.example 43	300	0.659	0.341	165.2	0.298	0.666	153.7	0.134	0.160	112.7
E.example 44	350	0.671	0.329	175.3	0.305	0.644	145.6	0.136	0.165	105.2

[0082]

Table 8

		Red			Green			Blue		
	Thickness of SiN (nm)	x	y	Brightness	x	y	Brightness	x	y	Brightness
E.example 45	50	0.664	0.336	141.1	0.285	0.663	139.1	0.140	0.152	102.1
E.example 46	100	0.668	0.320	155.8	0.320	0.641	141.9	0.133	0.206	102.7
E.example 47	150	0.669	0.331	121.6	0.320	0.631	121.9	0.146	0.176	111.6
E.example 48	200	0.664	0.336	129.7	0.287	0.664	139.9	0.136	0.171	107.2
E.example 49	300	0.670	0.330	130.4	0.317	0.633	126.3	0.144	0.168	110.7
E.example 50	350	0.665	0.335	123.0	0.292	0.662	139.2	0.135	0.188	110.1

[0083]

Table 9

red			Green			Blue		
x	Y	Brightness	X	Y	Brightness	x	Y	Brightness
0.667	0.334	114.2	0.317	0.635	115.3	0.145	0.202	112.5

[0084] Referring to Tables 5 to 9, in Experimental examples 9 to 50, when the thickness of the first refraction layer was fixed to 60 nm, and the thickness of the second refraction layer was changed within a range greater than 0 to not exceeding 350 nm, the brightness of red and green light was increased in every range as compared with Comparative example 6, and the brightness of blue light was decreased in y value of color coordinates or increased in brightness. Particularly, when the second refraction layer was formed to a thickness of 20 to 100 nm or 150 to 350 nm, and preferably 50 to 80 nm or 180 to 200 nm, the increase in brightness was greater than that in other ranges of thickness.

[0085] As described above, when the first refraction layer, a low refraction layer, is formed to a thickness of 100 nm or less, the light extraction efficiency and color reproducibility can be improved. In addition, when the second refraction layer, a high refraction layer, is formed to a thickness greater than 0 and not exceeding 350 nm, preferably 20 to 100 nm or 150 to 350 nm, and more particularly 50 to 80 nm or 180 to 200 nm, and even formed to the same thickness as the first refraction layer, an OLED display device can have enhanced light extraction efficiency and color coordinates, and thus can have improved color reproducibility with respect to red, green and blue light having a wavelength range from 400 to 800 nm.

[0086] According to the present invention, as thicknesses of first and second refraction layers disposed between an electrode and a transparent substrate are controlled, an OLED display device can have improved brightness and color coordinate characteristics in all emission wavelength ranges using a simple structure and process and thus enhanced light extraction efficiency and color reproducibility.

[0087] Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles of the invention, the scope of which is defined in the claims and their equivalents.

Claims

1. An organic light emitting diode (OLED) display device, comprising:

a substrate;
a first electrode disposed on the substrate;
an organic layer disposed on the first electrode and including an emission layer;
a second electrode disposed on the organic layer; and
first and a second refraction layer, disposed either between the first electrode and the substrate or on the second electrode; wherein a refractive index of the first refraction layer is smaller than a refractive index of the second refraction layer, and the first refraction layer has a thickness of 100 nm or less.

2. An OLED display device according to claim 1, wherein the second refraction layer has a thickness of 350 nm or less.

3. An OLED display device according to claim 2, wherein the thickness of the second refraction layer is either from 20 nm to 100 nm, or from 150 nm to 350 nm.

4. An OLED display device according to claim 3, wherein the thickness of the second refraction layer is either from 50 nm to 80 nm, or from 180 nm to 200 nm.

5. An OLED display device according to according to any preceding claim, wherein the refractive index of the second refraction layer is 1.1 times greater than the refractive index of the first refraction layer.

6. An OLED display device according to any preceding claim, wherein: the first and second refraction layers are disposed between the first electrode and the substrate, and the refractive index of the first refraction layer is smaller than a refractive index of the first electrode; or the first and second refraction layers are disposed on the second electrode, and the refractive index of the first refraction layer is smaller than a refractive index of the second electrode.

7. An OLED display device according to any preceding claim, wherein the refractive index of the first refraction layer is from 1.4 to 1.8.

8. An OLED display device according to any preceding, wherein each of the first and second refraction layers includes niobium oxide (Nb_2O_5), tantalum oxide (Ta_2O_5) titanium oxide (Ti_2O_5), silicon nitride (Si_xN_y), silicon oxide (SiO_2), antimony oxide (Sb_2O_3), aluminum oxide (Al_2O_3), zirconium oxide (ZrO_2), magnesium oxide (MgO), Hafnium oxide (HfO_2) or synthetic polymer.

9. An OLED display device according according to any preceding claim, wherein the first electrode is a transmissive electrode, the second electrode is a reflective electrode, the first refraction layer is disposed between the first electrode and the substrate, and the second refraction layer is disposed between the first refraction layer and the substrate.

10. An OLED display device according to one of claims 1 to 8, wherein the first electrode is a reflective electrode, the second electrode is a transmissive electrode, the first refraction layer is disposed on the second electrode, and the second refraction layer is disposed on the first refraction layer.

11. An OLED display device according to any preceding claim, wherein the first refraction layer of and the second refraction layer have substantially the same thicknesses.

12. An OLED display device according to any preceding claim:

wherein the substrate includes a plurality of unit pixel regions;
a plurality of organic light emitting diodes are disposed on the unit pixel regions of the substrate; and the said first electrode, second electrode, organic layer and first and a second refraction layers, together at least partially define one of the said organic light emitting diodes, each of the other said organic light emitting diodes being correspondingly configured.

13. An OLED display device according to any preceding claim, further comprising:

a third refraction layer either disposed between the second refraction layer and the substrate, if the first and second refraction layers are disposed between the first electrode and the substrate, or disposed on the second refraction layer, if the first and second refraction layers are disposed on the second electrode; wherein the third refraction layer has a refractive index that is the same as the refractive index of the first refraction layer, and a thickness that is the same as the thickness of the first refraction layer.

14. An OLED display device according to any preceding claim, wherein one organic layer emitting light having a longer wavelength is thicker than another organic layer emitting light having a shorter wavelength.

15. An OLED display device according to any preceding claim, further comprising:

a color filter disposed between the second refraction layer and the substrate, if the first and second refraction layers are disposed between the first electrode and the substrate.

16. An OLED display device according to one of claims 1 to 14, further comprising:

a color filter disposed on the second refraction layer, if the first and second refraction layers are disposed on the second electrode.

FIG. 1

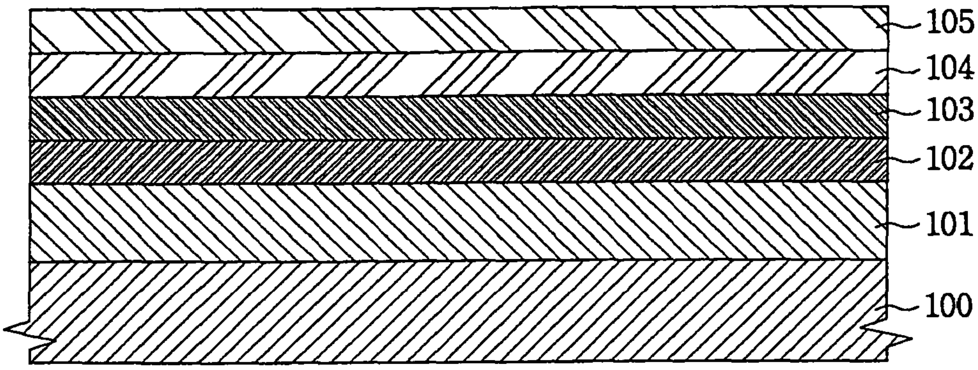


FIG. 2

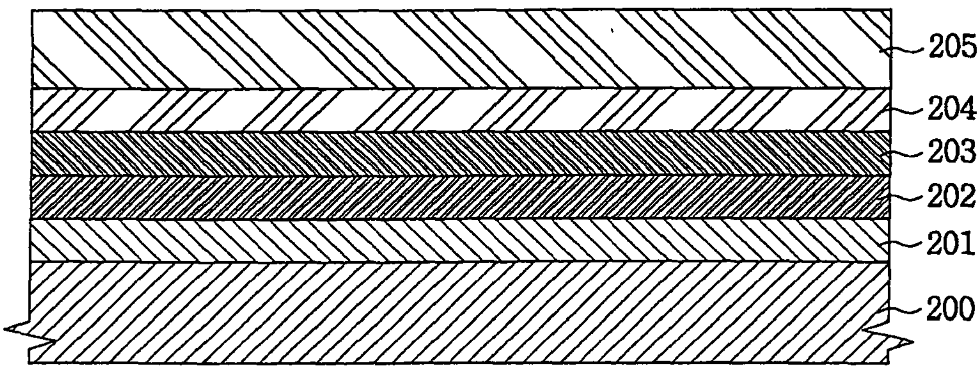


FIG. 3

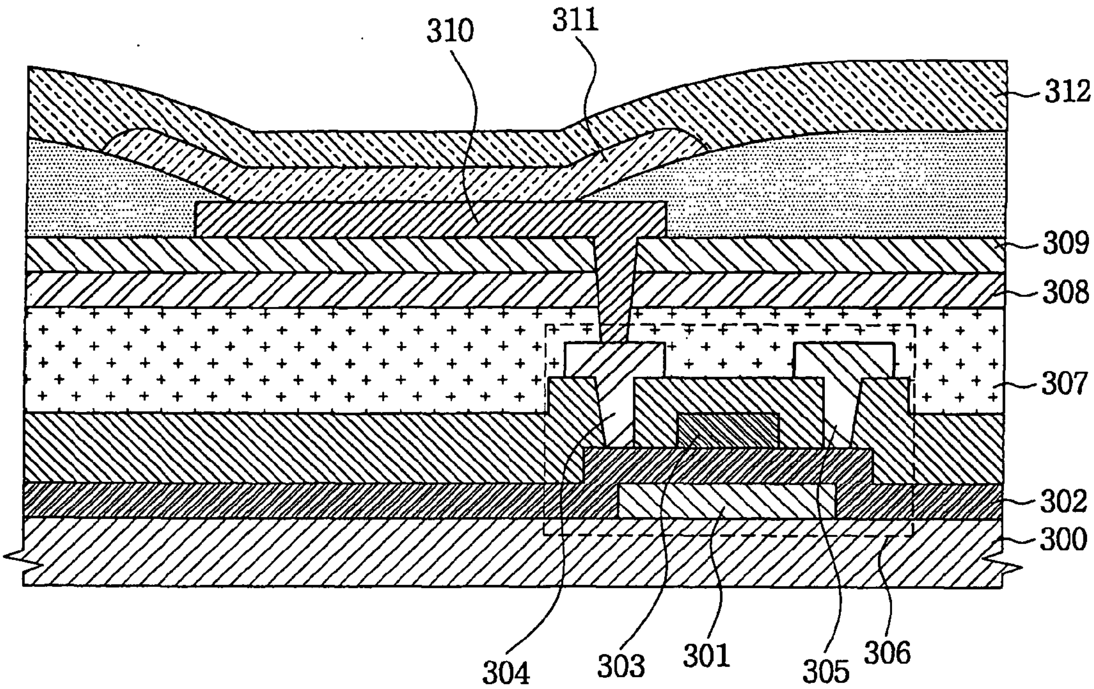
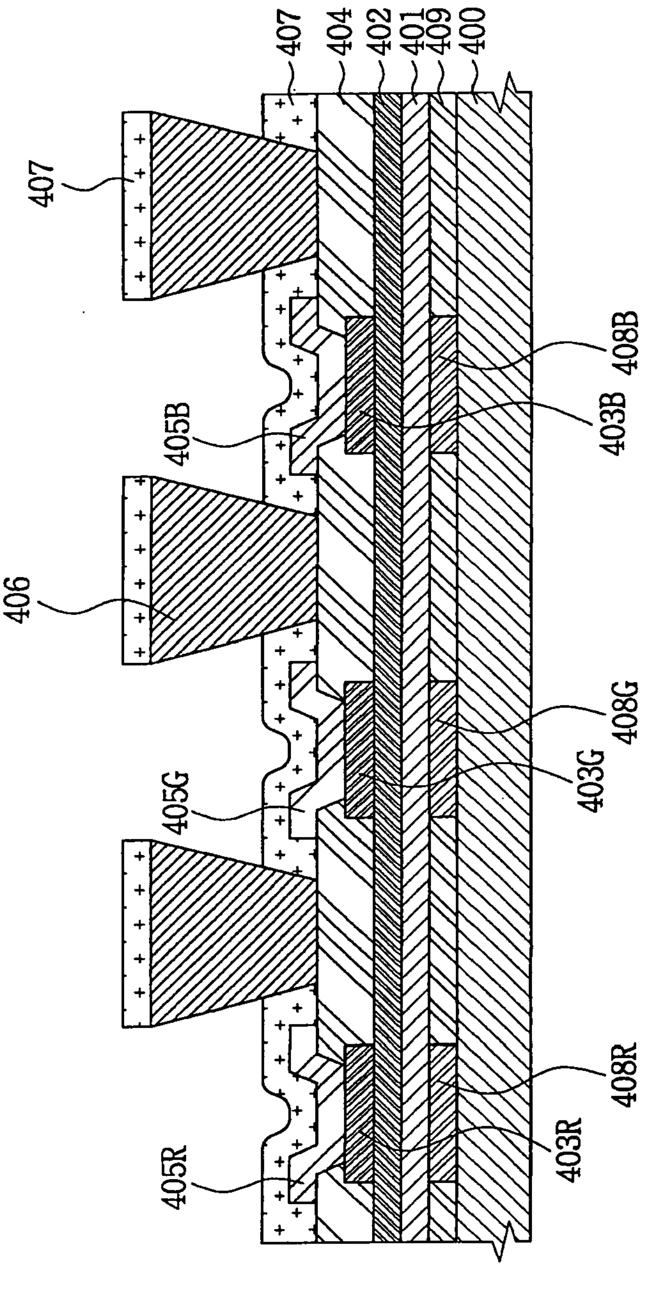


FIG. 4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EUROPEAN SEARCH REPORT

Application Number
EP 09 25 1503

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 September 2009	Pusch, Catharina

CATEGORY OF CITED DOCUMENTS

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18-09-2009

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专利名称(译)	有机发光二极管显示装置		
公开(公告)号	EP2131411A1	公开(公告)日	2009-12-09
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[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星移动显示器有限公司.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	JUN HYUK SANG SONG OK KEUN JEONG HYE IN YOUNG MO KOO		
发明人	JUN, HYUK-SANG SONG, OK KEUN JEONG, HYE-IN YOUNG-MO, KOO		
IPC分类号	H01L51/52		
CPC分类号	H01L51/5275 H01L51/5265 H01L2251/558		
优先权	1020080053339 2008-06-05 KR		
其他公开文献	EP2131411B1		
外部链接	Espacenet		

摘要(译)

一种有机发光二极管显示装置，其能够改善所有发光波长范围内的亮度和色坐标特性，因此可以提高光提取效率和色彩再现性。有机发光二极管显示装置包括基板（100），设置在基板上的第一电极（103），设置在第一电极（103）上并具有发光层的有机层，设置在第二电极（105）上的第二电极（105）有机层，以及第一（102）和第二（101）折射层。第一（102）和第二（101）折射层的叠层设置在第一电极（103）和基板（100）之间或第二电极上。第一折射层的折射率小于第二折射层的折射率。第一折射层的厚度不大于100nm。

FIG. 1