US 20190157358A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2019/0157358 A1**

MAEDA (43) **Pub. Date: May 23, 2019**

(54) **ORGANIC ELECTROLUMINESCENCE DISPLAY DEVICE**

(71) Applicant: **Japan Display Inc.**, Minato-ku (JP)

(72) Inventor: **Norihisa MAEDA**, Minato-ku (JP)

(73) Assignee: **Japan Display Inc.**, Minato-ku (JP)

(21) Appl. No.: **16/194,987**

(22) Filed: **Nov. 19, 2018**

(30) **Foreign Application Priority Data**

Nov. 21, 2017 (JP) 2017-223965

Publication Classification

(51) **Int. Cl.**

H01L 27/32 (2006.01)
H01L 51/52 (2006.01)
H01L 51/00 (2006.01)

(52) **U.S. Cl.**

CPC ***H01L 27/3211*** (2013.01); ***H01L 51/5221*** (2013.01); ***H01L 51/5275*** (2013.01); *H01L 51/5088* (2013.01); ***H01L 51/5206*** (2013.01); ***H01L 51/0081*** (2013.01); *H01L 27/3244* (2013.01); ***H01L 51/5265*** (2013.01)

(57) **ABSTRACT**

There is provided an organic EL display device having a first subpixel region and a second subpixel region. The organic EL display device includes a first light emission film, a second light emission film, an upper electrode, a cap layer configured to include a high refractive index film, a middle refractive index film, and a low refractive index film whose refractive indices are different from one another on an upper layer side of the upper electrode, and the low refractive index film is disposed to be distant from the substrate more than the other films included in the cap layer are, in the first and second subpixel regions. The middle refractive index film of the first subpixel region is formed to be thicker than the middle refractive index film of the second subpixel region.

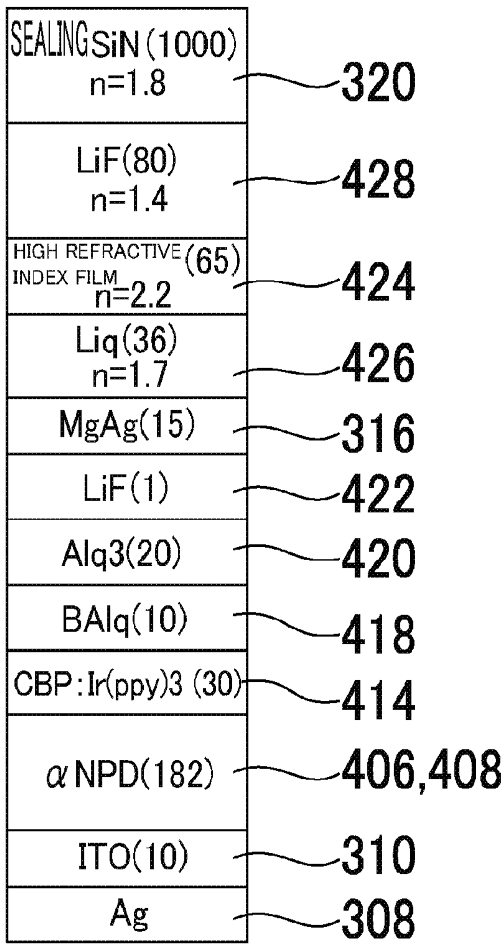


FIG.1

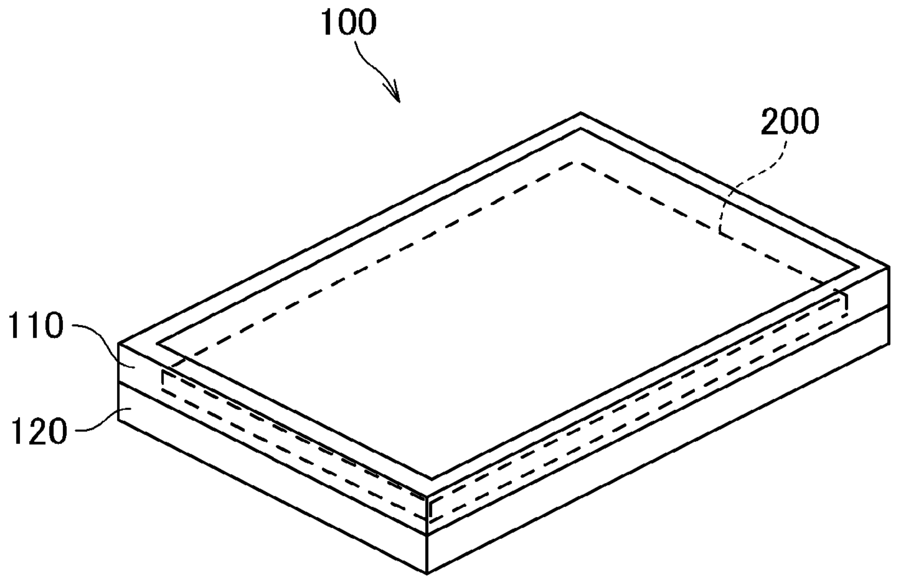


FIG.2

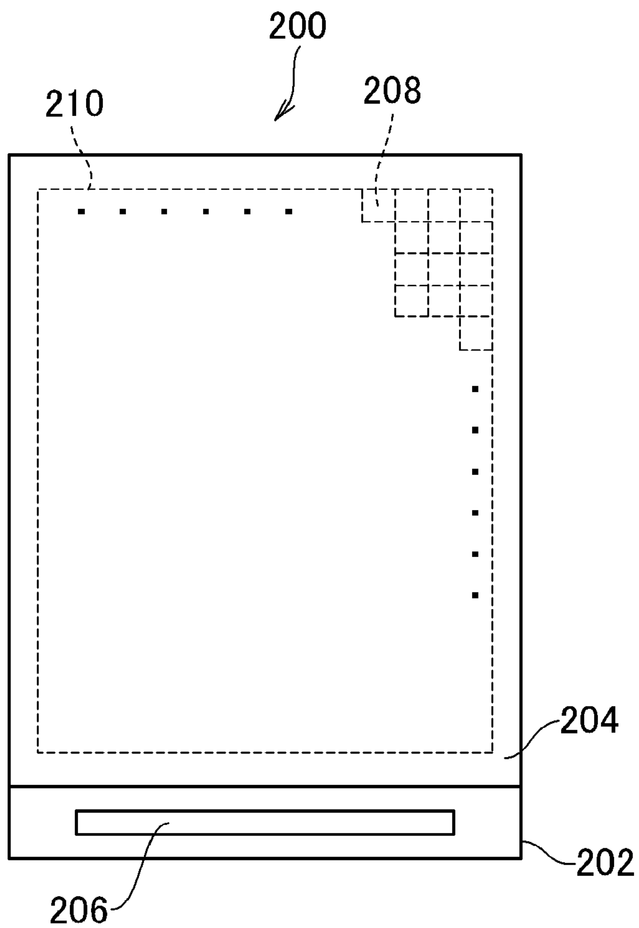


FIG.3

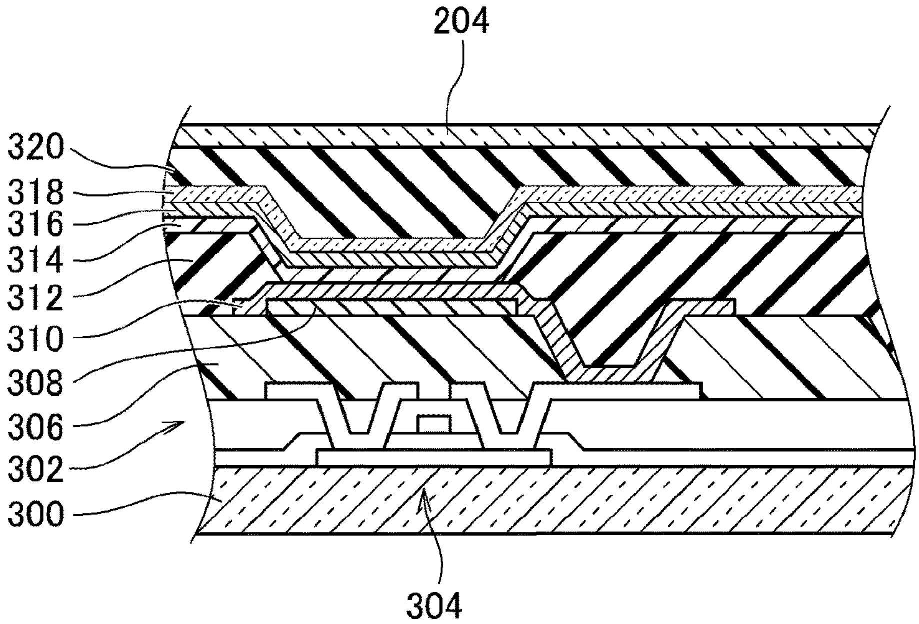


FIG.4A

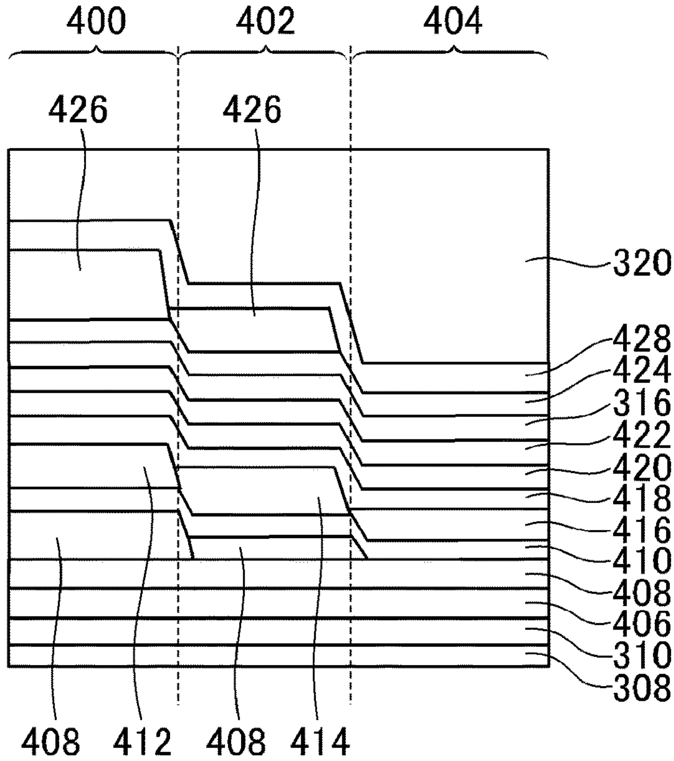

400
402
404
426
426
320
428
424
316
422
420
418
416
410
408
406
310
308
408
412
408
414

FIG.4B

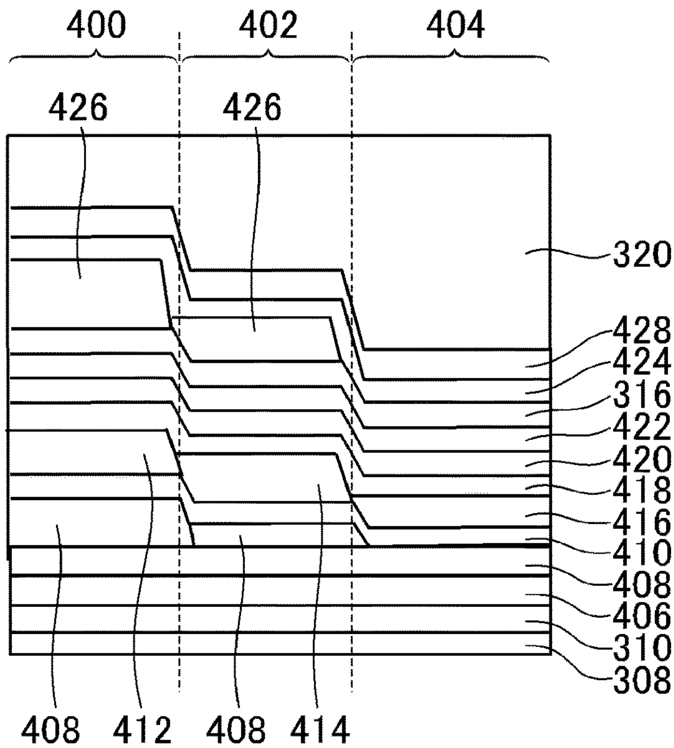

400
402
404
426
426
320
428
424
316
422
420
418
416
410
408
406
310
308
408
412
408
414

FIG.5A

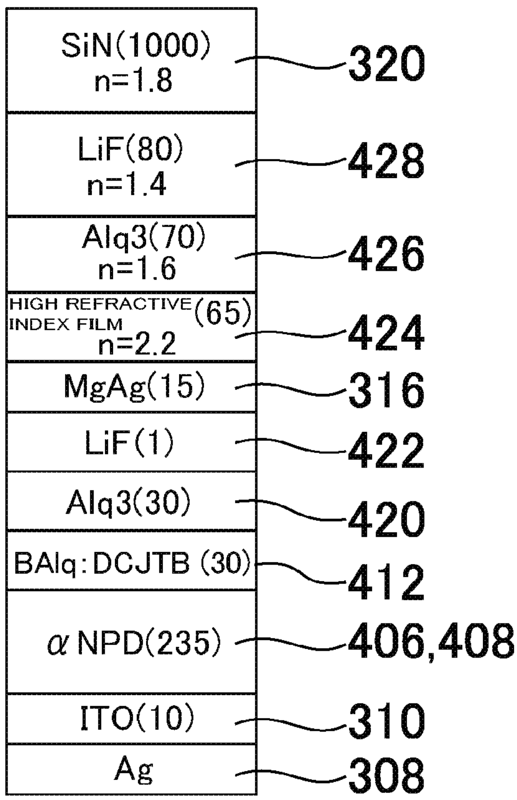

SiN(1000)
n=1.8
320
LiF(80)
n=1.4
428
Alq3(70)
n=1.6
426
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
MgAg(15)
316
LiF(1)
422
Alq3(30)
420
BAlq:DCJTB (30)
412
α NPD(235)
406,408
ITO(10)
310
Ag
308

FIG.5B

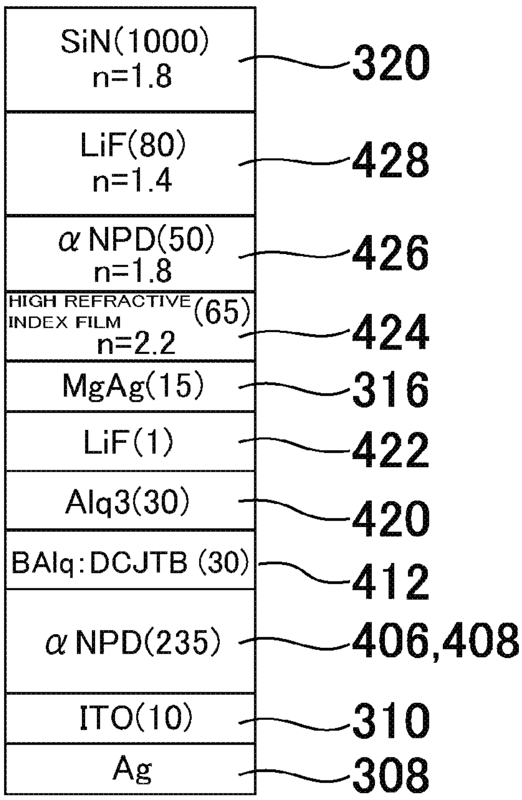

SiN(1000)
n=1.8
320
LiF(80)
n=1.4
428
αNPD(50)
n=1.8
426
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
MgAg(15)
316
LiF(1)
422
Alq3(30)
420
BAlq:DCJTB (30)
412
αNPD(235)
406,408
ITO(10)
310
Ag
308

FIG.5C

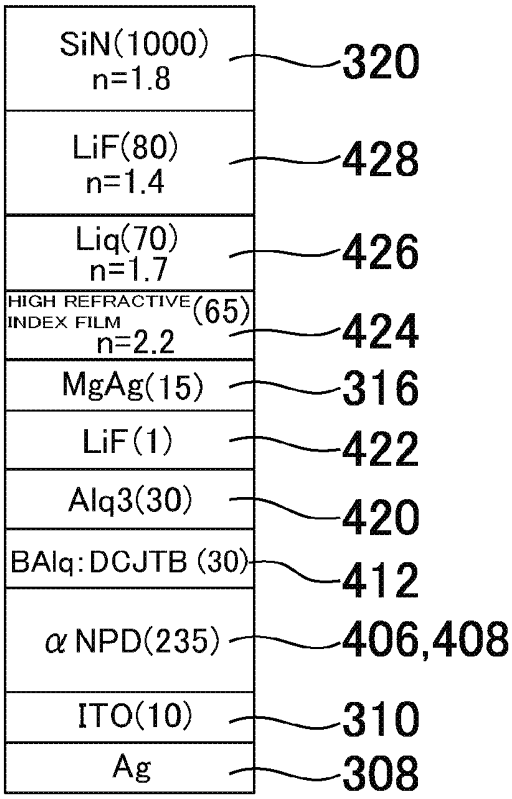

SiN(1000)
n=1.8
320
LiF(80)
n=1.4
428
Liq(70)
n=1.7
426
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
MgAg(15)
316
LiF(1)
422
Alq3(30)
420
BAlq:DCJTB (30)
412
α NPD(235)
406,408
ITO(10)
310
Ag
308

FIG.6A

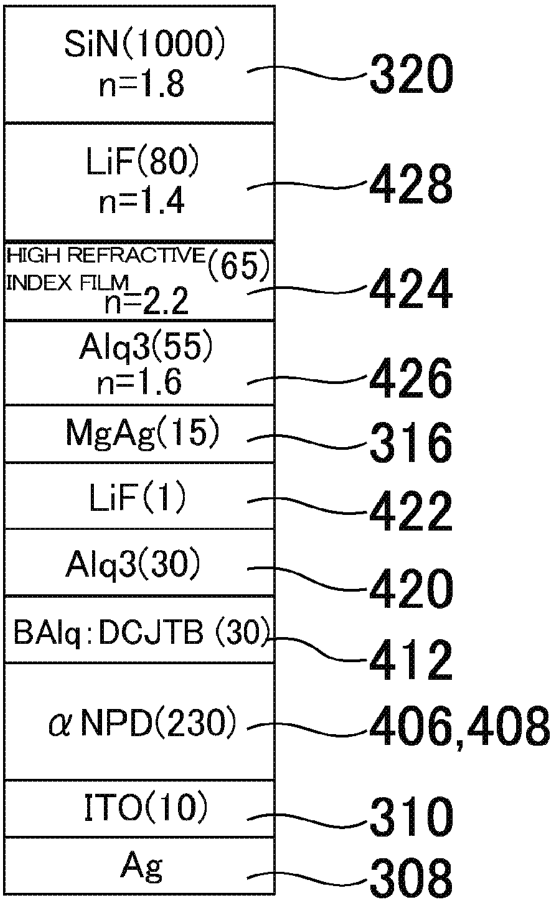

SiN(1000)
n=1.8
320
LiF(80)
n=1.4
428
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
Alq3(55)
n=1.6
426
MgAg(15)
316
LiF(1)
422
Alq3(30)
420
BAlq:DCJTB (30)
412
α NPD(230)
406,408
ITO(10)
310
Ag
308

FIG.6B

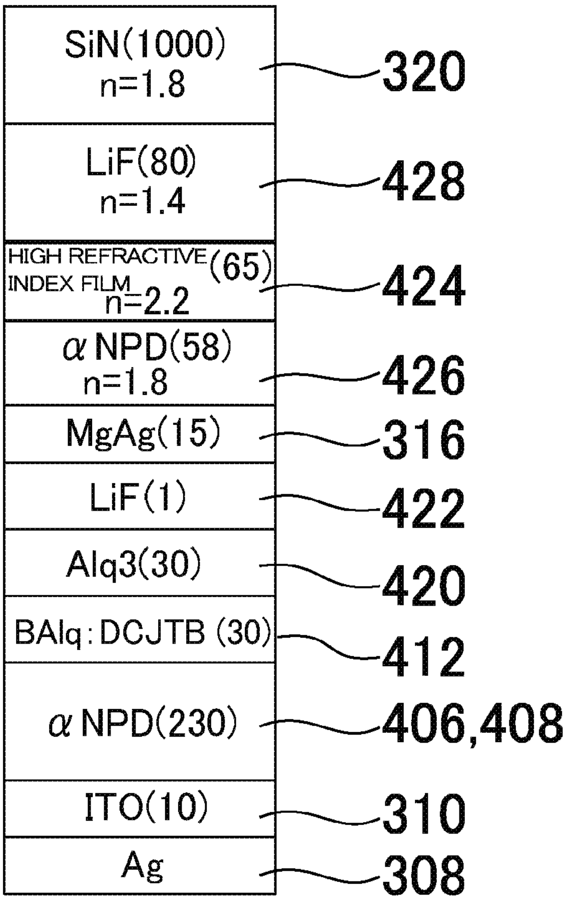

SiN(1000)
n=1.8
320
LiF(80)
n=1.4
428
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
αNPD(58)
n=1.8
426
MgAg(15)
316
LiF(1)
422
Alq3(30)
420
BAlq:DCJTB (30)
412
αNPD(230)
406,408
ITO(10)
310
Ag
308

FIG.6C

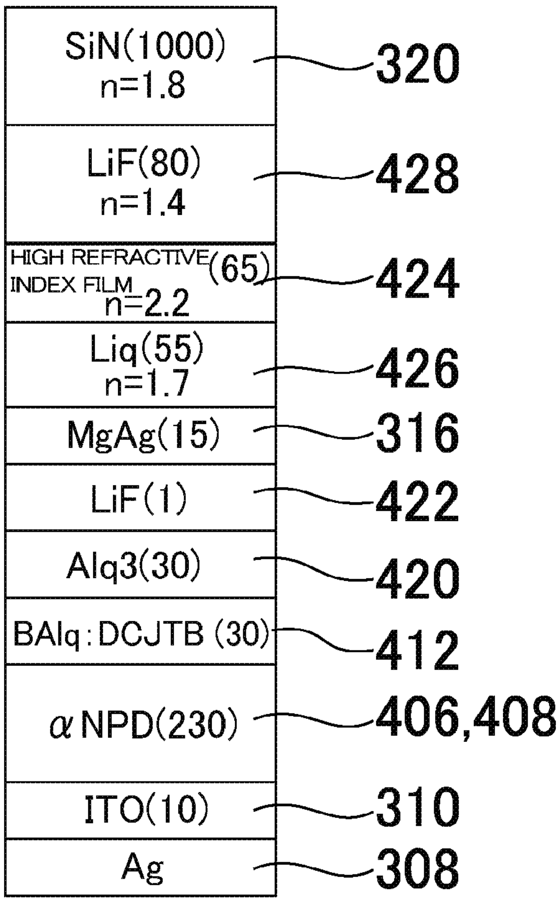

SiN(1000)
n=1.8
320
LiF(80)
n=1.4
428
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
Liq(55)
n=1.7
426
MgAg(15)
316
LiF(1)
422
Alq3(30)
420
BAlq : DCJTB (30)
412
αNPD(230)
406,408
ITO(10)
310
Ag
308

FIG. 7A

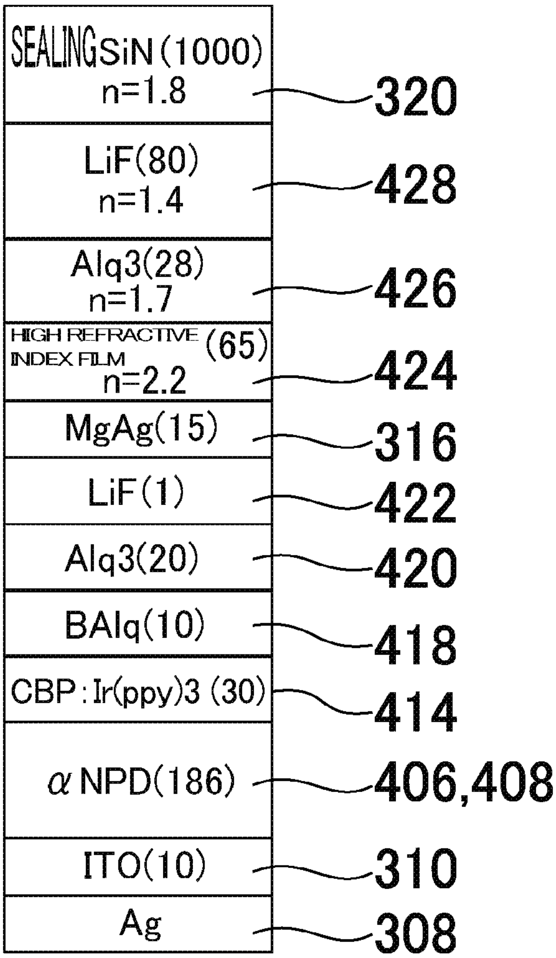

SEALING SiN (1000)
n=1.8
320
LiF(80)
n=1.4
428
Alq3(28)
n=1.7
426
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
MgAg(15)
316
LiF(1)
422
Alq3(20)
420
BAlq(10)
418
CBP:Ir(ppy)3 (30)
414
αNPD(186)
406,408
ITO(10)
310
Ag
308

FIG.7B

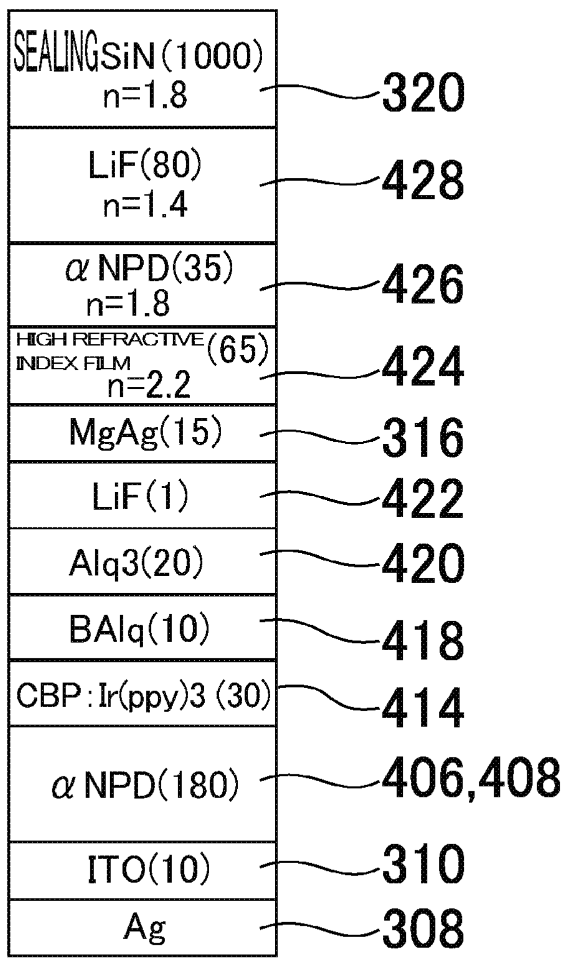

SEALING SiN (1000)
n=1.8
320
LiF(80)
n=1.4
428
α NPD(35)
n=1.8
426
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
MgAg(15)
316
LiF(1)
422
Alq3(20)
420
BAlq(10)
418
CBP : Ir(ppy)3 (30)
414
α NPD(180)
406,408
ITO(10)
310
Ag
308

FIG. 7C

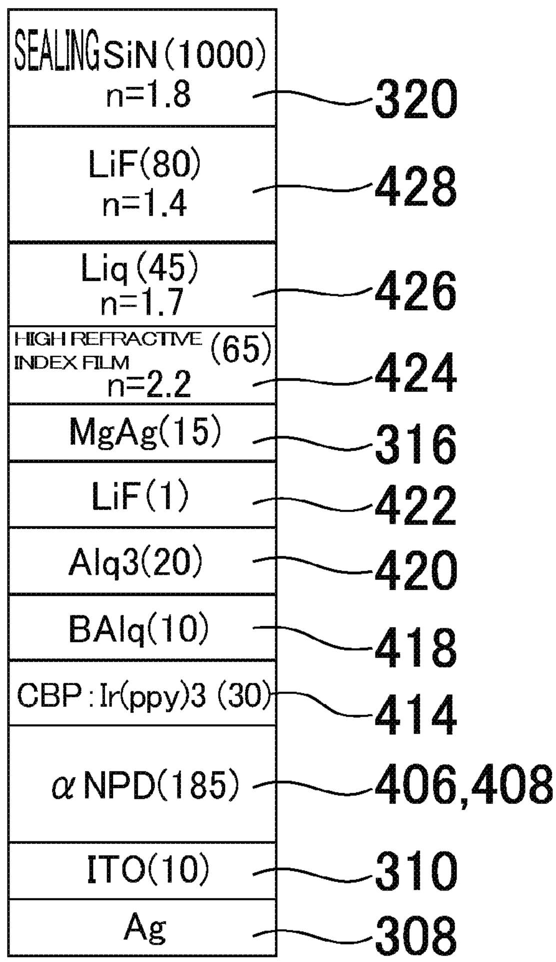

SEALING SiN (1000)
n=1.8
320
LiF(80)
n=1.4
428
Liq (45)
n=1.7
426
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
MgAg(15)
316
LiF(1)
422
Alq3(20)
420
BAlq(10)
418
CBP : Ir(ppy)3 (30)
414
αNPD(185)
406,408
ITO(10)
310
Ag
308

FIG.8A

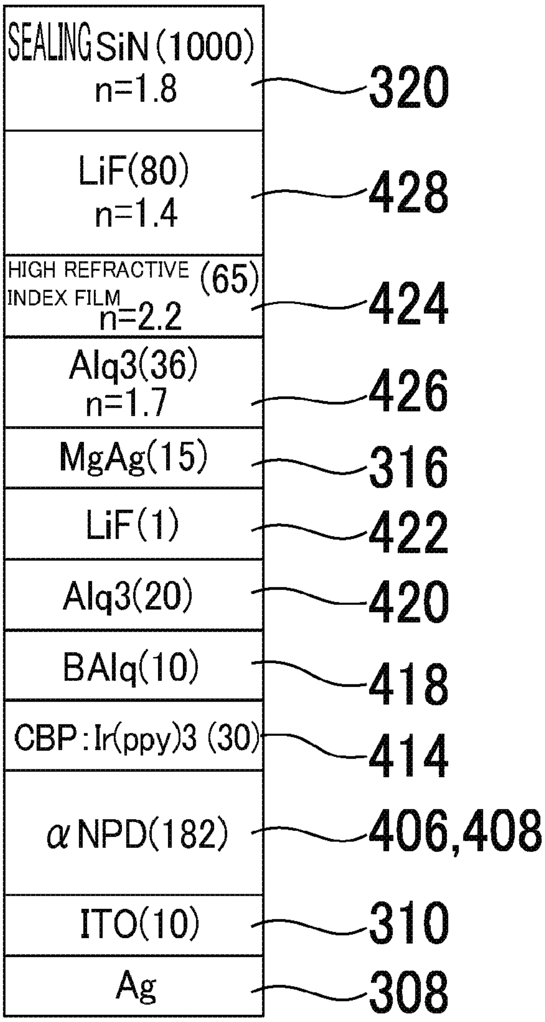

SEALING SiN (1000)
n=1.8
320
LiF(80)
n=1.4
428
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
Alq3(36)
n=1.7
426
MgAg(15)
316
LiF(1)
422
Alq3(20)
420
BAlq(10)
418
CBP:Ir(ppy)3 (30)
414
αNPD(182)
406,408
ITO(10)
310
Ag
308

FIG.8B

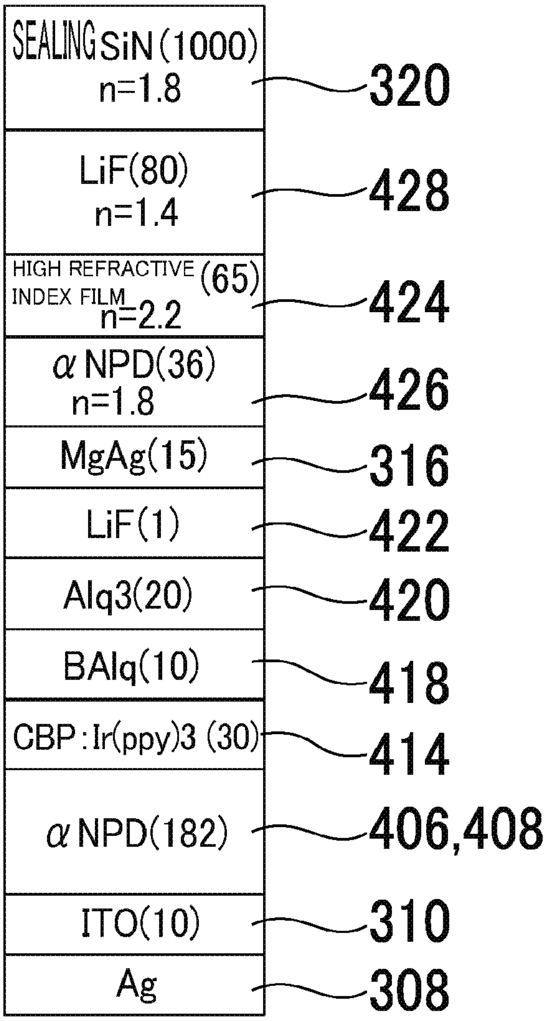
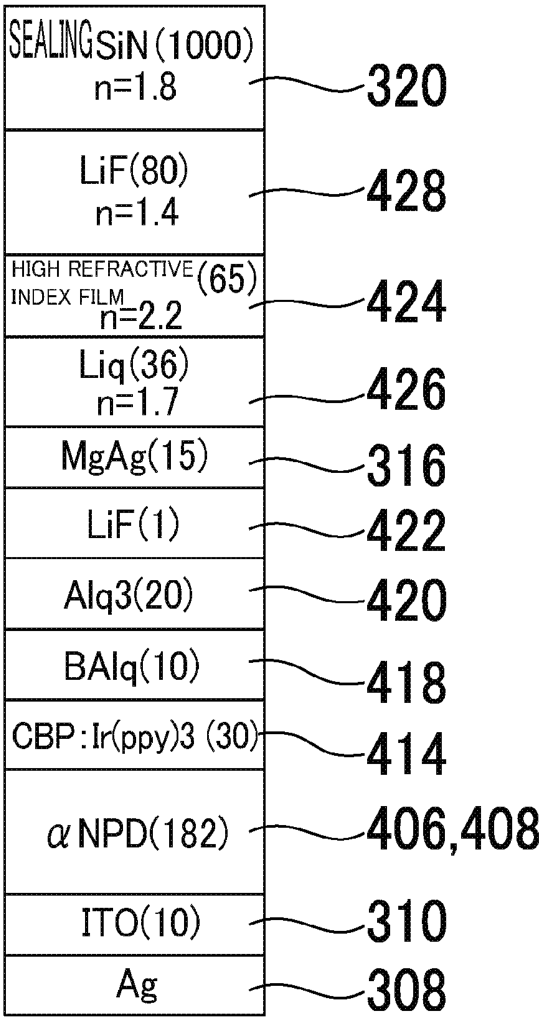

SEALING SiN (1000)
n=1.8
320
LiF(80)
n=1.4
428
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
α NPD(36)
n=1.8
426
MgAg(15)
316
LiF(1)
422
Alq3(20)
420
BAlq(10)
418
CBP : Ir(ppy)3 (30)
414
α NPD(182)
406,408
ITO(10)
310
Ag
308

FIG.8C


SEALING SiN (1000)
n=1.8
320
LiF(80)
n=1.4
428
HIGH REFRACTIVE INDEX FILM (65)
n=2.2
424
Liq(36)
n=1.7
426
MgAg(15)
316
LiF(1)
422
Alq3(20)
420
BAlq(10)
418
CBP:Ir(ppy)3 (30)
414
αNPD(182)
406,408
ITO(10)
310
Ag
308

ORGANIC ELECTROLUMINESCENCE DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority from the Japanese Application JP2017-223965 filed on Nov. 21, 2017, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] One or more embodiments of the present invention relate to an organic EL display device.

2. Description of the Related Art

[0003] Recent years, an organic EL display device which uses an organic EL element has been put into a practical use. There is a case where a cap layer is provided in an organic EL display device in order to improve an efficiency of extracting light emitted by an organic EL element. For example, Japanese Patent Application Laid-Open No. 2017-004980 discloses providing a cap layer of different thickness for each pixel which emits light of different wavelength.

[0004] Further, Japanese Patent Application Laid-Open No. 2015-099773 discloses a configuration where a cap layer is constituted by two different types of layers having different refractive indices, and thickness of a cap layer having a high refractive index is different at each subpixel, for improving the efficiency of extracting light. By this configuration, light emitted by an organic EL element is reflected at an interface of the two different kinds of layers, and thus a so-called microcavity structure is formed.

SUMMARY OF THE INVENTION

[0005] In order to form the microcavity structure, it is necessary to adjust an optical path length in accordance with a wavelength of light, by changing the thickness of the cap layer. Therefore, in the case light is emitted whose wavelength varies on a subpixel-by-subpixel basis, it is necessary to adjust the thickness of the cap layer for each subpixel.

[0006] However, in Japanese Patent Application Laid-Open No. 2015-099773, an optical path length is adjusted by changing thickness of a cap layer whose refractive index is high. In this case, the optical path length largely changes according to a slight change of the thickness of the cap layer, and thus it is difficult to adjust the optical path length.

[0007] The present invention has been made in view of the problems as described above, and the object thereof is to provide an organic EL display device having a microcavity structure with which an optical wave length can be easily adjusted.

[0008] According to one aspect of the present invention, there is provided an organic EL display device having a first subpixel region and a second subpixel region, including a substrate, a first light emission film which is disposed on the substrate of the first subpixel region and emits first light, a second light emission film which is disposed on the substrate of the second subpixel region and emits second light whose wavelength is shorter than that of the first light, an upper electrode which is disposed on an upper layer side of the first light emission film and the second light emission film and has conductivity, light transmissivity, and light reflectivity at the same time and a cap layer configured to include a high refractive index film, a middle refractive index film, and a low refractive index film whose refractive indices are different from one another on an upper layer side of the upper electrode, and the low refractive index film is disposed to be distant from the substrate more than the other films included in the cap layer are, in the first and second subpixel regions. The middle refractive index film of the first subpixel region is formed to be thicker than the middle refractive index film of the second subpixel region.

[0009] In the above-mentioned aspects of the invention, the high refractive index film is disposed to be close to the substrate more than the other films included in the cap layer are.

[0010] In the above-mentioned aspects of the invention, the middle refractive index film is disposed to be close to the substrate more than the other films included in the cap layer are.

[0011] In the above-mentioned aspects of the invention, the middle refractive index film is formed of Alq3, alpha-NPD, or Liq.

[0012] In the above-mentioned aspects of the invention, a microcavity structure is formed so that lights, which are emitted from the first and second light emission films and have wavelengths different from each other, resonate between the cap layer and the upper electrode.

[0013] In the above-mentioned aspects of the invention, the organic EL display device further includes a third subpixel region where a third light emission film to emit third light having a wavelength shorter than that of the second light, the upper electrode, and the cap layer are disposed on the substrate. The cap layer in the third subpixel region is configured to include the high refractive index film and the low refractive index film.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is a diagram which schematically shows an organic EL display device according to an embodiment of the present invention.

[0015] FIG. **2** is a diagram which schematically shows a display panel.

[0016] FIG. **3** is an exemplary diagram which schematically shows a lamination structure of a cross section of the display panel.

[0017] FIG. **4**A is a diagram which schematically shows respective layers formed between a reflective film and an upper electrode of one pixel.

[0018] FIG. **4**B is a diagram which schematically shows the respective layers formed between the reflective film and the upper electrode of one pixel.

[0019] FIG. **5**A is a diagram which schematically shows respective layers of a first subpixel region.

[0020] FIG. **5**B is a diagram which schematically shows the respective layers of the first subpixel region.

[0021] FIG. **5**C is a diagram which schematically shows the respective layers of the first subpixel region.

[0022] FIG. **6**A is a diagram which schematically shows the respective layers of the first subpixel region.

[0023] FIG. **6**B is a diagram which schematically shows the respective layers of the first subpixel region.

[0024] FIG. **6**C is a diagram which schematically shows the respective layers of the first subpixel region.

[0025] FIG. 7A is a diagram which schematically shows respective layers of a second subpixel region.

[0026] FIG. 7B is a diagram which schematically shows the respective layers of the second subpixel region.

[0027] FIG. 7C is a diagram which schematically shows the respective layers of the second subpixel region.

[0028] FIG. 8A is a diagram which schematically shows the respective layers of the second subpixel region.

[0029] FIG. 8B is a diagram which schematically shows the respective layers of the second subpixel region.

[0030] FIG. 8C is a diagram which schematically shows the respective layers of the second subpixel region.

DETAILED DESCRIPTION OF THE INVENTION

[0031] Below, each of the one or more embodiments of the present invention is described with reference to the accompanying drawings. Note that the one or more disclosed embodiments are merely examples, and an appropriate variation which a person skilled in the art can easily arrive at without departing from the spirit of the present invention is naturally included in the scope of the present invention. Further, while the width, thickness, shape, and the like of each part in the drawings may be shown schematically as compared with the actual embodiments in order to clarify the description, these are merely examples, and an interpretation of the present invention should not be limited thereto. Furthermore, in the specification and the respective drawings, the same reference symbols may be applied to elements similar to those which have already been shown in another drawing, and a detailed description of such elements may be omitted as appropriate.

[0032] FIG. **1** is a diagram which schematically shows an organic EL display device **100** according to an embodiment of the present invention. As shown in the FIG. **1**, the organic EL display device **100** is composed of a display panel **200** which is fixed so as to be sandwiched by an upper frame **110** and a lower frame **120**.

[0033] FIG. **2** is a diagram which schematically shows the display panel **200** of FIG. **1**. The display panel **200** has an array substrate **202**, a protection film **204**, and a drive IC (Integrated Circuit) **206**.

[0034] Further, the display panel **200** has pixels **208** which are arranged in a matrix in a display region **210**. Specifically, the display panel **200** has a plurality of pixels each of which has first to third subpixel regions **400**, **402**, and **404**. On each of the first to third subpixel regions **400**, **402**, and **404**, an organic EL layer **314**, an upper electrode **316**, a cap layer **318**, and the like which will be respectively described later are disposed. Organic EL layers **314** disposed on the first to third subpixel regions **400**, **402**, and **404** respectively emit lights of different wavelengths. Note that the number of subpixel regions which the plurality of pixels have is not limited to be three, and it can be four or more.

[0035] On the array substrate **202**, an array layer **302**, first to third light emission films **412**, **414**, and **416**, a hole transport layer **408**, and the like to be described later are formed.

[0036] The drive IC **206**, for example, applies an electric potential to a drive transistor **304** arranged in each subpixel region for electrically connecting its source and drain, and at the same time sends an electric current corresponding to a gradation value to the respective data signal lines. By the drive IC **206**, the display panel **200** displays, on the display region **210**, a color image constituted by a plurality of pixels **208** of a plurality of colors.

[0037] The protection film **204** is an acrylic film which protects the display panel **200** from an external damage, and is bonded to the array substrate **202** by adhesive.

[0038] FIG. **3** is a diagram which schematically shows a cross section of the display panel **200**. As shown in the FIG. **3**, the display panel **200** is configured to include the substrate **300**, the array layer **302**, the planarizing film **306**, the reflection film **308**, the lower electrode **310**, the rib **312**, the organic EL layer **314**, the upper electrode **316**, the cap layer **318**, the sealing film **320**, and the protection film **204** in this order, starting from the lower side to the upper side in the FIG. **3**.

[0039] The substrate **300** is, for example, a glass substrate, but may also be a flexible substrate made of resin.

[0040] The array layer **302** is formed on the substrate **300**. Specifically, the array layer **302** is formed on the substrate **300** so as to include a plurality of drive transistors **304** which are configured to include a source electrode, a drain electrode, a gate electrode, a semiconductor layer, and the like.

[0041] The planarizing film **306** is formed of an insulating material on the array layer **302**. Specifically, the planarizing film **306** is formed of an insulating material so as to have a through hole on the upper side of either of the source electrode or the drain electrode of the drive transistor **304**, and so as to cover the array layer **302** in a region other than a region where the through hole is formed.

[0042] The reflection film **308** is formed, on the planarizing film **306**, of a material which reflects light emitted from the organic EL layer **314**. Specifically, the reflection film **308** is formed, for example, of Ag.

[0043] The lower electrode **310** is formed on the reflection film **308** and the planarizing film **306**. Specifically, the lower electrode **310** is formed of a material which is transparent and conductive such as ITO or the like, so as to cover the reflection film **308**, and so as to be connected electrically to the source electrode or the drain electrode of the drive transistor **304** via the through hole. It may be configured to form the lower electrode **310** with metal to have the lower electrode **310** function as the reflection film **308** as well. That is, it may be configured that the reflection film **308** is not provided.

[0044] The rib **312** is formed on the lower electrode **310**. Specifically, the rib **312** is formed such that it covers the planarizing film **306** in a region where the lower electrode **310** is not formed, and that it is formed on the lower electrode **310** in a region where the lower electrode **310** formed. Further, the rib **312** is formed such that it has a rib opening part on the upper layer side of a region where the reflection film **308** is formed. The rib opening part is a region where the light is extracted from the display panel **200**.

[0045] The organic EL layer **314** is configured to include the first to third light emission films **412**, **414**, and **416** which emit light, the hole transport layer **408**, and the like. Specifically, the first light emission film **412** is disposed on the substrate **300** of the first subpixel region **400**, and emits first light. The second light emission film **414** is disposed on the substrate **300** of the second subpixel region **402**, and emits second light whose wavelength is shorter than that of the first light. The third light emission film **416** is disposed on the substrate **300** of the third subpixel region **404**, and emits third light whose wavelength is shorter than that of the second light. The hole transport layer **408** and the like will be described later.

[0046] The upper electrode **316** is formed, on an upper layer side of the first light emission film **412** and the second light emission film **414**, of a material which has conductivity, light transmissivity, and light reflectivity. Specifically, the upper electrode **316** is formed so as to cover the organic EL layer **314**. The upper electrode **316** is formed of a material which has conductivity as well as light transmissivity and light reflectivity (referred to also as semi-transmitting reflectivity) such as MgAg. The upper electrode **316** supplies electrons to the organic EL layer **314** to thereby have the organic EL layer **314** emit light.

[0047] The cap layer **318** is configured to include a high refractive index film **424**, a middle refractive index film **426**, and a low refractive index film **428** whose refractive indices are different from one another in the first and second subpixel regions **400** and **402**, on the upper layer side of the upper electrode **316**. The low refractive index film **428** is disposed to be distant from the substrate **300** more than the other films included in the cap layer **318** are. Specifically, the cap layer **318** is, in the first and second subpixel regions **400** and **402**, composed of at least three types of layers whose refractive indices are different from one another. The cap layer **318** includes the high refractive index film **424** whose refractive index is high, the low refractive index film **428** whose refractive index is lower than that of the high refractive index film **424**, and the middle refractive index film **426** whose refractive index is lower than that of the high refractive index film **424** but is higher than that of the low refractive index film **428**. Further, the cap layer **318** is composed of at least two types of layers whose refractive indices are different from each other in the third subpixel region **404**. The detailed structure of the cap layer **318** is described with reference to FIG. **4**.

[0048] The sealing layer **320** is formed on the cap layer **318**. Specifically, the sealing layer **320** is formed of an inorganic material which does not allow the permeation of moisture, so as to cover the cap layer **318**. The sealing layer **320** prevents deterioration of the organic EL layer **314** due to the permeation of moisture into the organic EL layer **314**.

[0049] Subsequently, the details of the cap layer **318** is described with reference to FIG. **4**A and FIG. **4**B. FIG. **4**A and FIG. **4**B are diagrams which schematically show the respective layers formed between the reflection film **308** and the sealing film **320** in the rib opening part of one pixel **208**. As shown in FIG. **4**A, at each pixel **208**, the reflection film **308**, the lower electrode **310**, a hole injection layer **406**, a hole transport layer **408**, an electron block layer **410**, the first to third light emission films **412**, **414**, and **416**, a hole block layer **418**, an electron transport layer **420**, an electron injection layer **422**, the upper electrode **316**, the high refractive index film **424**, the middle refractive index film **426**, and the low refractive index film **428**, and the sealing film **320** are laminated.

[0050] Note that FIG. **4**A and FIG. **4**B are schematic diagrams, and the reflection film **308** and the lower electrode **310** are illustrated such that they are continuously formed over the first to third subpixel regions **400**, **402**, and **404**, but actually the reflection film **308** and the lower electrode **310** are disposed discontinuously at each of the first to third subpixel regions **400**, **402**, and **404**. Note that FIG. **4**A and FIG. **4**B schematically show the structure where the first subpixel region **400**, the second subpixel region **402**, and the third subpixel region **404** are arranged in this order, starting from the left. Further, the hole transport layer **408** and the electron transport layer **420** are also referred to as a charge transport layer. Moreover, the layers from the hole injection layer **406** to the electron injection layer **422** correspond to the organic EL layer **314** in FIG. **3**.

[0051] The hole injection layer **406** is formed on the lower electrode **310**. Specifically, the hole injection layer **406** is formed on the lower electrode **310** in the first to third subpixel regions **400**, **402**, and **404**.

[0052] Further, the hole injection layer **406** is formed of a material which has a function of supplying the hole transport layer **408** with holes injected from the lower electrode **310**. For example, the hole injection layer **406** is, in order to lower the hole injection barrier, formed of a material having the HOMO level whose energy level gap with respect the Fermi level of the material used for the lower electrode **310** is small.

[0053] The hole transport layer **408** is formed to have different thicknesses in the respective first to third subpixel regions **400**, **402**, and **404**. Specifically, the hole transport layer **408** is arranged to have a uniform thickness on the hole injection layer **406**, in all of the first to third subpixel regions **400**, **402**, and **404**. Further, an additional hole transport layer **408** is, in the first and second subpixel regions **400** and **402**, further disposed on the hole transport layer **408** described as above.

[0054] Here, the hole transport layer **408** disposed on the first subpixel region **400** is formed to be thicker than the hole transport layer **408** disposed on the second subpixel region **402**. By this configuration, distances between the reflection film **308** and the first to third light emission films **412**, **414**, and **416** are, in the first to third subpixel regions **400**, **402**, and **404** respectively, lengths with which the lights emitted by the first to third light emission films **412**, **414**, and **416** resonate. By this configuration, the microcavity structure is formed between the reflection film **308** and the first to third light emission films **412**, **414**, and **416**.

[0055] Further, the hole transport layer **408** is formed of a material having a function to supply the first to third light emission films **412**, **414**, and **416** with the holes supplied by the hole injection layer **406**. For example, it is preferable to form the hole transport layer **408** with a material having a HOMO level whose energy level gap with respect to a HOMO level of the hole injection layer **406** is small.

[0056] The electron block layer **410** is formed on the hole transport layer **408**. Specifically, the hole block layer **418** is formed, in the first to third subpixel regions **400**, **402**, and **404**, of a material having a function to prevent the electrons supplied to the first to third light emission films **412**, **414**, and **416** by the electron transport layer **420** from reaching the hole transport layer **408**.

[0057] The first light emission film **412** is disposed on the electron block layer **410** in the first subpixel region **400**. The first light emission film **412** is formed of a material which emits, for example, red light.

[0058] The second light emission film **414** is disposed on the electron block layer **410** in the second subpixel region **402**. The second light emission film **414** is formed of a material which emits, for example, green light.

[0059] The third light emission film **416** is disposed on the electron block layer **410** in the third subpixel region **404**.

The third light emission film **416** is formed of a material which emits, for example, blue light.

[0060] The hole block layer **418** is formed on the first to third light emission films **412**, **414**, and **416**. Specifically, the hole block layer **418** is formed, on the first to third light emission films **412**, **414**, and **416**, of a material having a function to prevent the holes supplied to the first to third light emission films **412**, **414**, and **416** by the hole transport layer **408** from reaching the electron transport layer **420**.

[0061] The electron transport layer **420** is formed on the hole block layer **418**. Specifically, the electron transport layer **420** is formed, on the hole block layer **418**, of a material having a function to supply the first to third light emission films **412**, **414**, and **416** with the electrons supplied by the upper electrode **316**.

[0062] The electron injection layer **422** is formed on the electron transport layer **420**. Specifically, in the first to third subpixel regions **400**, **402**, and **404**, the electron injection layer **422** is formed on the electron transport layer **420**. Further, the electron injection layer **422** is formed of a material having a function to supply the electron transport layer **420** with the electrons injected from the upper electrode **316**.

[0063] The high refractive index film **424** is disposed on the upper electrode **316**. Specifically, as shown in FIG. **4**A, the high refractive index film **424** is disposed close to the substrate **300** more than the other films included in the cap layer **318** are. The high refractive index film **424** is formed of a material having a refractive index higher than those of the low refractive index film **428** and the middle refractive index film **426**.

[0064] The middle refractive index film **426** is disposed on the high refractive index film **424**. Specifically, the middle refractive index film **426** is formed on the high refractive index film **424** of the first subpixel region **400** and the second subpixel region **402**. Further, the middle refractive index film **426** of the first subpixel region **400** is formed to be thicker than the middle refractive index film **426** of the second subpixel region **402**.

[0065] The low refractive index film **428** is disposed on the middle refractive index film **426** and the high refractive index film **424**. Specifically, the low refractive index film **428** is disposed on the middle refractive index film **426** in the first and second subpixel regions **400** and **402**. Further, the low refractive index film **428** is disposed on the high refractive index film **424** in the third subpixel region **404**.

[0066] As has been described above, the cap layer **318** is constituted by the high refractive index film **424**, the middle refractive index film **426**, and the low refractive index film **428**. The cap layer **318** in the first and second subpixel regions **400** and **402** is configured to include the high refractive index film **424**, the middle refractive index film **426**, and the low refractive index film **428**. The cap layer **318** in the third subpixel region **404** is configured to include the high refractive index film **424**, and the low refractive index film **428**.

[0067] By the configuration of the cap layer **318** as described above, the microcavity structure is formed so that the lights of different wavelengths emitted from the first and second light emission films **412** and **414** resonates between the cap layer **318** and the upper electrode **316**. Specifically, the lights emitted from the first to third light emission films **412**, **414**, and **416** are reflected at an interface between layers with different refractive indices. Therefore, the lights are reflected at the interface between the high refractive index film **424** and the middle refractive index film **426** and the interface between the middle refractive index film **426** and the low refractive index film **428** (hereinafter referred to as the interfaces inside the cap layer **318**).

[0068] As has been described above, the middle refractive index film **426** is formed with different thicknesses in the first and second subpixel regions **400** and **402** respectively, in accordance with the wavelengths of lights emitted from the first and second light emission films **412** and **414**. Further, in the third subpixel region **404**, the middle refractive index film **426** is not disposed. By this configuration, the distances between the upper electrode **316** and the interfaces inside the cap layer **318** become the lengths with which the lights emitted by the first to third light emission films **412**, **414**, and **416** resonate in the first to third subpixel regions **400**, **402**, and **404**, respectively. Therefore, the microcavity structure is formed between the upper electrode **316** and the interfaces inside the cap layer **318**.

[0069] Here, in order that the microcavity structure may be formed, the optical path lengths between the upper electrode **316** and the interfaces inside the cap layer **318** in the first to third subpixel regions **400**, **402**, and **404** need to be integral multiples of the wavelengths of the lights emitted from the first to third light emission films **412**, **414**, and **416**, respectively. In the case where the optical path lengths are adjusted by controlling the thickness of the high refractive index film **424**, even a slight change in the thickness of the high refractive index film **424** greatly changes the optical path lengths. Meanwhile, in the case where the optical path lengths are adjusted by controlling the thickness of the medium refractive index film **426**, the change in the optical path lengths due to the thickness change can be reduced as compared with the case where the adjustment is performed by controlling the thickness of the high refractive index film **424**. By this configuration, the adjustment of the optical path lengths can be made more easily.

[0070] Note that the middle refractive index film **426** may be arranged close to the substrate **300** more than the other films included in the cap layer **318** are. Specifically, as shown in FIG. **4**B, the middle refractive index film **426** may be disposed on the upper electrode **316** in the first and second subpixel regions **400** and **402**. In this case, the high refractive index film **424** is disposed on the middle refractive index film **426** in the first and second subpixel regions **400** and **402**. Further, the high refractive index film **424** is disposed on the upper electrode **316** in the third subpixel region **404**. Moreover, the low refractive index film **428** is disposed on the high refractive index film **424**. Even in this configuration, the microcavity structure can be formed between the upper electrode **316** and the interfaces inside the cap layer **318**, as in the configuration as shown in FIG. **4**A.

[0071] Further, the middle refractive index film **426** may be disposed also in the third subpixel region **404**. In this case, the middle refractive index film **426** of the third subpixel region **404** is formed to be thinner than the middle refractive index film **426** of the second subpixel region **402**, in accordance with the wavelength of light emitted from the third light emission film **416**. Even in such a configuration, the microcavity structure can be formed between the upper electrode **316** and the interfaces inside the cap layer **318**, as in the above cases.

[0072] Subsequently, specific materials and thicknesses of the respective layers configured as shown in FIG. **4**A are described. FIGS. **5**A to **5**C are schematic diagrams which show the configurations of the reflection film **308** to the sealing film **320** in the first subpixel region **400**.

[0073] As shown in FIG. **5**A, the lower electrode **310** is formed of ITO (Indium Tin Oxide) to be as thick as 10 nm. The hole injection layer **406** and the hole transport layer **408** are formed of naphthyl-substituted benzidine (alpha-NPD) to be as thick as 235 nm. As to the first light emission film **412**, the host is Bis(2-methyl-8-quinolinolato)-4-(phenylphenolato)aluminum (BAlq), the light emission dopant is DCJTB (4-(Dicyanomethylene)-2-tert-butyl-6-(1,1,7,7-tetramethyljulolidin-4-yl-vinyl)-4H-pyran, 4-(dicyanomethylene)-2-tert-butyl-6-(1,1,7,7-tetramethyljulolidin-4-yl-vinyl)-4H-pyran), and the thickness of the first light emission film **412** is formed to be as thick as 30 nm. The electron transport layer **420** is formed of (Tris(8-hydroxyquinolinato) aluminum (Alq3) to be as thick as 30 nm. The electron injection layer **422** is formed of lithium fluoride (LiF) to be as thick as 1 nm. The upper electrode **316** is formed of magnesium silver (MgAg) to be as thick as 15 nm. The high refractive index film **424** is formed of an organic material whose refractive index is 2.2 to be as thick as 65 nm. The middle refractive index film **426** is formed of Alq3 to be as thick as 70 nm. Note that the refractive index of Alq3 is 1.6. The low refractive index film **428** is formed of LiF to be as thick as 80 nm. Note that the refractive index of LiF is 1.4. The sealing film **320** is formed of silicon nitride (SiN) to be as thick as 1000 nm. Note that the refractive index of SiN is 1.8.

[0074] The inventor examined the light emitted from the first subpixel region **400** having the configuration as shown in FIG. **5**A, and confirmed that they could obtain chromaticity and luminance the same as the ones which they would obtain if they replace the middle refractive index film **426** with the high refractive index film **424**. Specifically, they examined, as the comparison target, the configuration as shown in FIG. **5**A which had, instead of the high refractive index film **424** and the middle refractive index film **426** as shown in the figure, the high refractive index film **424** formed of an organic material with a refractive index of 2.2 and a thickness of 125 nm. As a result, in the configuration of the comparison target, the chromaticity of the light emitted from the first subpixel region **400** was (0.680, 0.315) in an xyz color system. Further, the luminance of the light was 19.9 cd/A. Meanwhile, the chromaticity of the light emitted from the first subpixel region **400** having the configuration as shown in FIG. **5**A was (0.680, 0.315). Further, the luminance of the light was 19.7 cd/A. Thus, it has been found that by the configuration having the middle refractive index film **426**, the chromaticity and the luminance the same as those of the configuration of the comparison target can be obtained.

[0075] Further, according to the embodiment as shown in FIG. **5**A as above, the usage amount of the material of the high refractive index film **424** can reduced as compared with the case of the configuration of the comparison target. The material having the high refractive index is expensive as compared with the material having the middle refractive index, and therefore the manufacturing cost of the organic EL display device **100** can be reduced.

[0076] Note that the middle refractive index film **426** may be formed of alpha-NPD. Specifically, as shown in FIG. **5**B, the middle refractive index film **426** may be formed of alpha-NPD to be as thick as 50 nm. Note that the refractive index of alpha-NPD is 1.8. The chromaticity of the light emitted from the first subpixel region **400** having the configuration as shown in FIG. **5**B was (0.680, 0.315). Further, the luminance of the light was 20.3 cd/A.

[0077] Further, the middle refractive index film **426** may be formed of 8-Hydroxyquinolinolato-lithium (Liq). Specifically, as shown in FIG. **5**C, the middle refractive index film **426** may be formed of Liq to be as thick as 70 nm. Note that the refractive index of Liq is 1.7. The chromaticity of the light emitted from the first subpixel region **400** having the configuration as shown in FIG. **5**C was (0.680, 0.315). Further, the luminance of the light was 19.8 cd/A. Thus, it has been found that by the configurations as shown in FIG. **5**B and FIG. **5**C, the chromaticity and the luminance the same as those of the configuration of the comparison target can be obtained.

[0078] Subsequently, as to the embodiment having the configuration as shown in FIG. **4**B, specific materials and thicknesses of the respective layers are described. The embodiments having the configurations as shown in FIGS. **6**A to **6**C are the same as the embodiments as shown in FIGS. **5**A to **5**C, except for the configuration of the middle refractive index film **426** and the high refractive index film **424**.

[0079] In the configuration as shown in FIG. **6**A, the middle refractive index film **426** is formed of Alq3 to be as thick as 55 nm on the upper electrode **316**. The high refractive index film **424** is formed of an organic material whose refractive index is 2.2 to be as thick as 65 nm on the middle refractive index film **426**. The chromaticity of the light emitted from the first subpixel region **400** having this configuration was (0.680, 0.316). Further, the luminance of the light was 20.2 cd/A.

[0080] In the configuration as shown in FIG. **6**B, the middle refractive index film **426** is formed of alpha-NPD to be as thick as 58 nm on the upper electrode **316**. The high refractive index film **424** is formed of an organic material whose refractive index is 2.2 to be as thick as 65 nm on the middle refractive index film **426**. The chromaticity of the light emitted from the first subpixel region **400** having this configuration was (0.680, 0.316). Further, the luminance of the light was 20.1 cd/A.

[0081] In the configuration as shown in FIG. **6**C, the middle refractive index film **426** is formed of Liq to be as thick as 55 nm on the upper electrode **316**. The high refractive index film **424** is formed of an organic material whose refractive index is 2.2 to be as thick as 65 nm on the middle refractive index film **426**. The chromaticity of the light emitted from the first subpixel region **400** having this configuration was (0.680, 0.316). Further, the luminance of the light was 20.2 cd/A. Thus, it has been found that by the configurations as shown in FIG. **6**B and FIG. **6**C, the chromaticity and the luminance the same as those of the configurations of the comparison targets can be obtained.

[0082] FIGS. **7**A to **7**C are schematic diagrams which show the configuration of the reflection film **308** to the sealing film **320** in the second subpixel region **402**.

[0083] As shown in FIG. **7**A, the lower electrode **310** is formed of ITO (Indium Tin Oxide) to be as thick as 10 nm. The hole injection layer **406** and the hole transport layer **408** are formed of alpha-NPD to be as thick as 186 nm. As to the second light emission film **414**, the host is 4,4'-Bis(carbazol-9-yl)biphenyl (CBP), the light emission dopant is Ir(ppy)3 (Tris[2-phenylpyridinato-C2,N]iridium (III)), and the thickness of the second light emission film **414** is formed to be as thick as 30 nm. The hole block layer **418** is formed of BAlq to be as thick as 10 nm. The electron transport layer **420** is formed of Alq3 to be as thick as 20 nm. The electron injection layer **422** is formed of lithium fluoride (LiF) to be as thick as 1 nm. The upper electrode **316** is formed of magnesium silver (MgAg) to be as thick as 15 nm. The high refractive index film **424** is formed of an organic material whose refractive index is 2.2 to be as thick as 65 nm. The middle refractive index film **426** is formed of Alq3 to be as thick as 28 nm. The low refractive index film **428** is formed of LiF to be as thick as 80 nm. The sealing film **320** is formed of silicon nitride (SiN) to be as thick as 1000 nm.

[0084] In the second subpixel region **402**, as in the first subpixel region **400**, the middle refractive index film **426** may be formed of alpha-NPD or Liq. Specifically, as shown in FIG. **7**B, the middle refractive index film **426** may be formed of alpha-NPD to be as thick as 35 nm. Further, as shown in FIG. **7**C, the middle refractive index film **426** may be formed of Liq to be as thick as 45 nm. Note that the thicknesses of the hole injection layers **406** and the hole transport layers **408** as shown in FIG. **7**B and FIG. **7**C are different from those of the hole injection layer **406** and the hole transport layer **408** as shown in FIG. **7**A, but those thicknesses are matters to be designed as appropriate.

[0085] Subsequently, specific materials and thicknesses of the respective layers (as shown in FIG. **4**B) in the second subpixel region **402** are described. The embodiments having the configurations as shown in FIGS. **8**A to **8**C are the same as the embodiments as shown in FIGS. **7**A to **7**C, except for the configuration of the hole transport layer **408**, the hole injection layer **406**, the middle refractive index film **426**, and the high refractive index film **424**. Note that the hole injection layer **406** and the hole transport layer **408** are different from each other in their thicknesses, but are the same as each other in that they are formed of alpha-NPD.

[0086] In the configuration as shown in FIG. **8**A, the middle refractive index film **426** is formed of Alq3 to be as thick as 36 nm on the upper electrode **316**. The high refractive index film **424** is formed of an organic material whose refractive index is 2.2 to be as thick as 65 nm on the middle refractive index film **426**.

[0087] In the configuration as shown in FIG. **8**B, the middle refractive index film **426** is formed of alpha-NPD to be as thick as 36 nm on the upper electrode **316**. The high refractive index film **424** is formed of an organic material whose refractive index is 2.2 to be as thick as 65 nm on the middle refractive index film **426**.

[0088] In the configuration as shown in FIG. **8**C, the middle refractive index film **426** is formed of Liq to be as thick as 36 nm on the upper electrode **316**. The high refractive index film **424** is formed of an organic material whose refractive index is 2.2 to be as thick as 65 nm on the middle refractive index film **426**.

[0089] As in the configurations as described above, the middle refractive index film **426** disposed in the second subpixel region **402** is formed to be as thick as approximately one third to two thirds of the thickness of the middle refractive index film **426** disposed in the first subpixel region **400**. Also in this configuration, as the cases described above, the microcavity structure can be formed between the upper electrode **316** and the interfaces inside the cap layer **318**. By this configuration, also in the second subpixel region **402**, the chromaticity and the luminance similar to those of the configuration not to have the middle refractive index film **426** can be obtained.

[0090] While there have been described what are at present considered to be certain embodiments of the invention, it will be understood that various modifications may be made thereto, and it is intended that the appended claims cover all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An organic EL display device having a first subpixel region and a second subpixel region, comprising:
- a substrate;
- a first light emission film which is disposed on the substrate of the first subpixel region and emits first light;
- a second light emission film which is disposed on the substrate of the second subpixel region and emits second light whose wavelength is shorter than that of the first light;
- an upper electrode which is disposed on an upper layer side of the first light emission film and the second light emission film and has conductivity, light transmissivity, and light reflectivity at the same time; and
- a cap layer configured to include a high refractive index film, a middle refractive index film, and a low refractive index film whose refractive indices are different from one another on an upper layer side of the upper electrode, and the low refractive index film is disposed to be distant from the substrate more than the other films included in the cap layer are, in the first and second subpixel regions, wherein
- the middle refractive index film of the first subpixel region is formed to be thicker than the middle refractive index film of the second subpixel region.

2. The organic EL display device according to claim **1**, wherein
- the high refractive index film is disposed to be close to the substrate more than the other films included in the cap layer are.

3. The organic EL display device according to claim **1**, wherein
- the middle refractive index film is disposed to be close to the substrate more than the other films included in the cap layer are.

4. The organic EL display device according to claim **1**, wherein
- the middle refractive index film is formed of Alq3, alpha-NPD, or Liq.

5. The organic EL display device according to claim **1**, wherein
- a microcavity structure is formed so that lights, which are emitted from the first and second light emission films and have wavelengths different from each other, resonate between the cap layer and the upper electrode.

6. The organic EL display device according to claim **1**, further comprising a third subpixel region where a third light emission film to emit third light having a wavelength shorter than that of the second light, the upper electrode, and the cap layer are disposed on the substrate, wherein
- the cap layer in the third subpixel region is configured to include the high refractive index film and the low refractive index film.

* * * * *

专利名称(译)	有机电致发光显示装置		
公开(公告)号	US20190157358A1	公开(公告)日	2019-05-23
申请号	US16/194987	申请日	2018-11-19
[标]申请(专利权)人(译)	株式会社日本显示器		
申请(专利权)人(译)	日本展示INC.		
当前申请(专利权)人(译)	日本展示INC.		
[标]发明人	MAEDA NORIHISA		
发明人	MAEDA, NORIHISA		
IPC分类号	H01L27/32 H01L51/52 H01L51/00		
CPC分类号	H01L27/3211 H01L51/5221 H01L51/5275 H01L51/5265 H01L51/5206 H01L51/0081 H01L27/3244 H01L51/5088 H01L51/5056 H01L51/5012 H01L51/5072 H01L51/5092 H01L2251/308 H01L51/5253 H01L2251/301 H01L2251/558		
优先权	2017223965 2017-11-21 JP		
外部链接	Espacenet USPTO		

摘要(译)

提供一种具有第一子像素区域和第二子像素区域的有机EL显示装置。有机EL显示装置包括第一发光膜，第二发光膜，上电极，配置为包括高折射率膜的盖层，中折射率膜和折射率为的低折射率膜。在上电极的上层侧彼此不同，并且在第一和第二子像素区域中，低折射率膜设置为比包括在盖层中的其他膜更远离基板。第一子像素区域的中折射率膜形成为比第二子像素区域的中折射率膜厚。