US 20200098831A1

(19) **United States**

(12) **Patent Application Publication**

SHIRAHASE

(10) **Pub. No.: US 2020/0098831 A1**

(43) **Pub. Date: Mar. 26, 2020**

(54) **ORGANIC ELECTROLUMINESCENCE ELEMENT, ORGANIC ELECTROLUMINESCENCE PANEL AND ELECTRONIC APPARATUS**

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(21) Appl. No.: **16/554,626**

(22) Filed: **Aug. 29, 2019**

(30) **Foreign Application Priority Data**

Sep. 20, 2018 (JP) 2018-175874
May 14, 2019 (JP) 2019-091166

Publication Classification

(51) **Int. Cl.**
H01L 27/32 (2006.01)
H01L 51/52 (2006.01)
H01L 51/50 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 27/3206*** (2013.01); ***H01L 51/5221*** (2013.01); *G09G 3/3233* (2013.01); ***H01L 51/5092*** (2013.01); ***H01L 51/5218*** (2013.01); ***H01L 51/5072*** (2013.01)

(57) **ABSTRACT**

Disclosed is an organic electroluminescence element including: an anode, a light emitting layer and a cathode in this order; and a low refractive index layer lower in refractive index than the light emitting layer at at least one of a position between the light emitting layer and the cathode and a position between the anode and the light emitting layer.

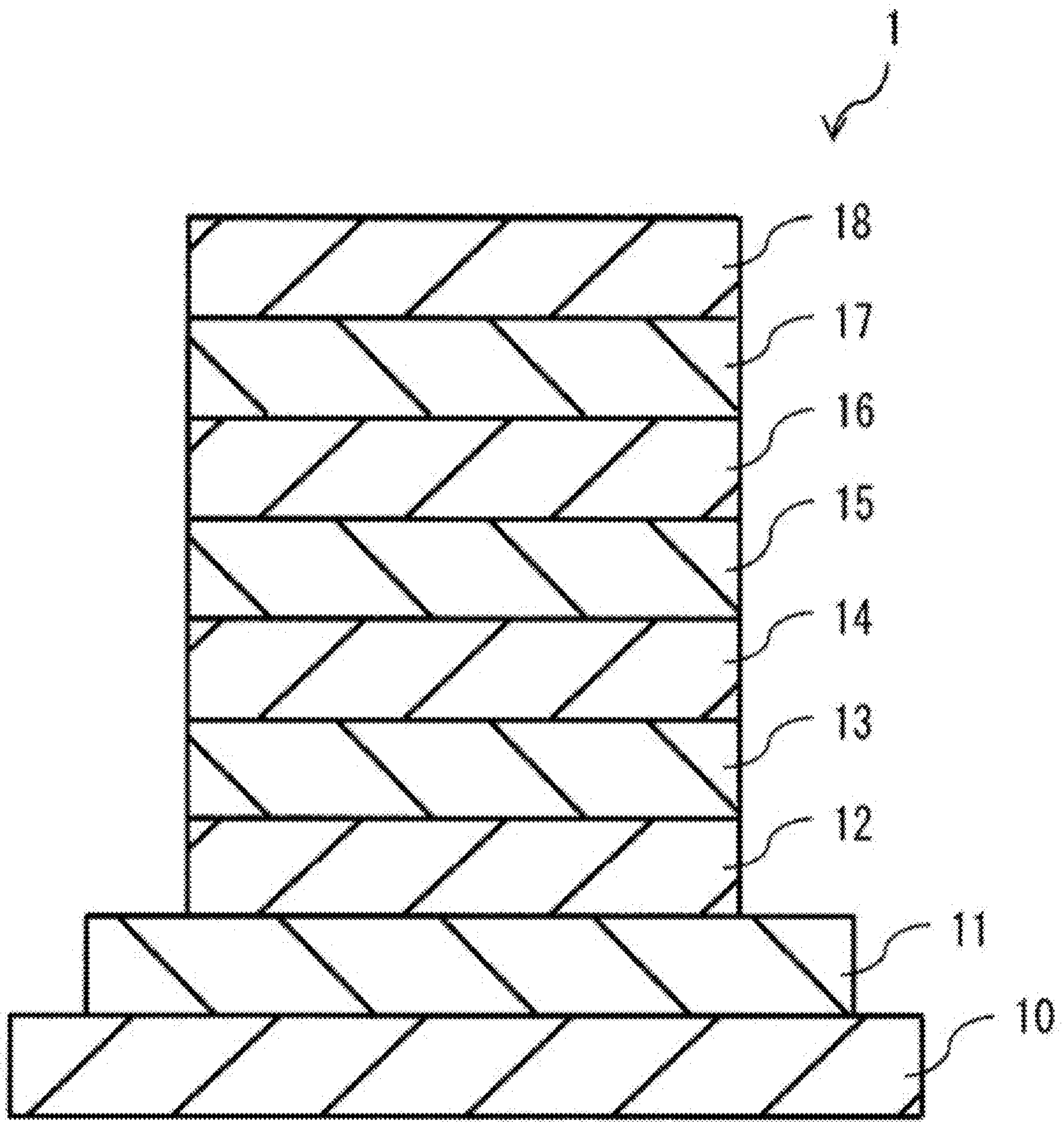


FIG. 1

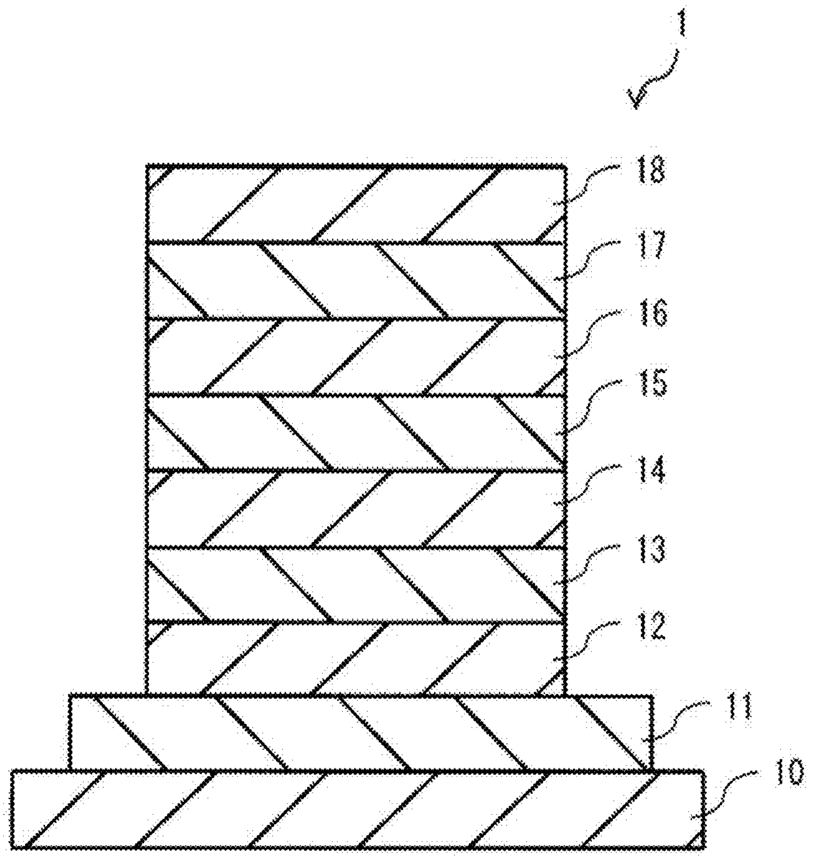


FIG. 2A

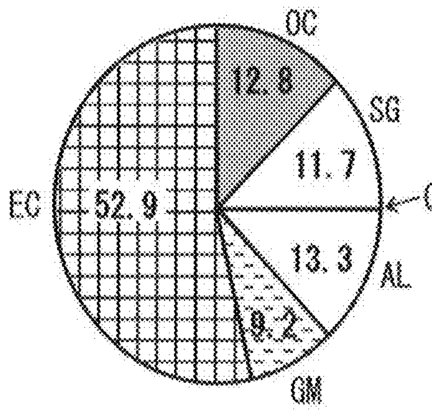


FIG. 2B

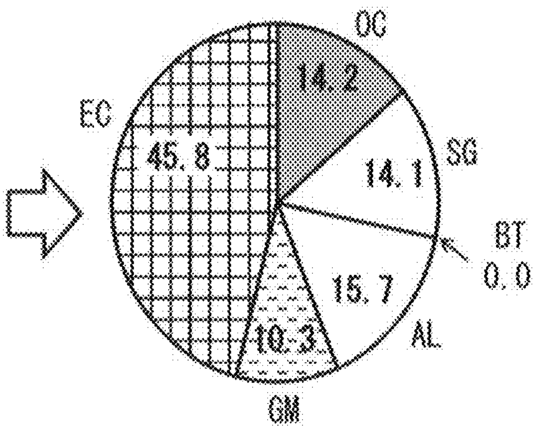


FIG. 3

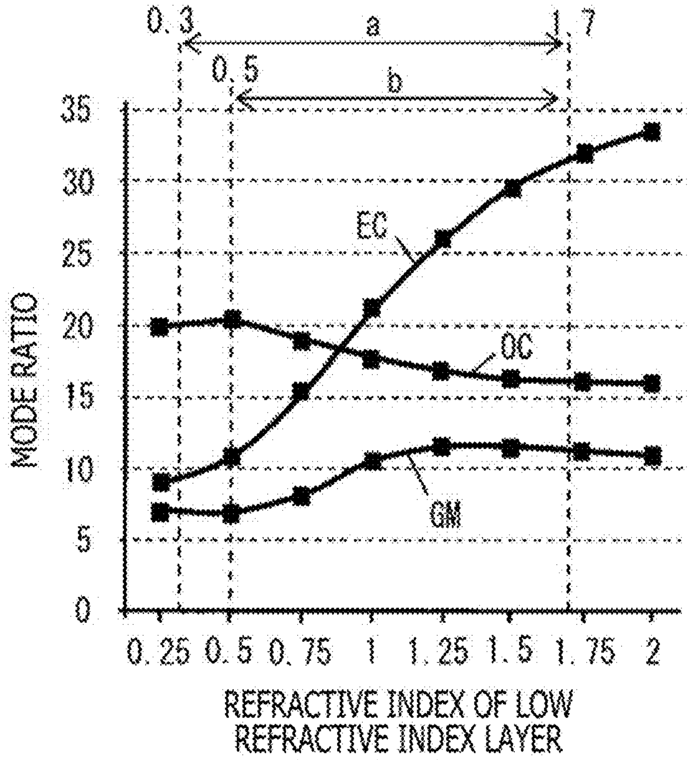

0.3
a
1.7
0.5
b
35
30
25
20
15
10
5
0
MODE RATIO
EC
OC
GM
0.25 0.5 0.75 1 1.25 1.5 1.75 2
REFRACTIVE INDEX OF LOW REFRACTIVE INDEX LAYER

FIG. 4

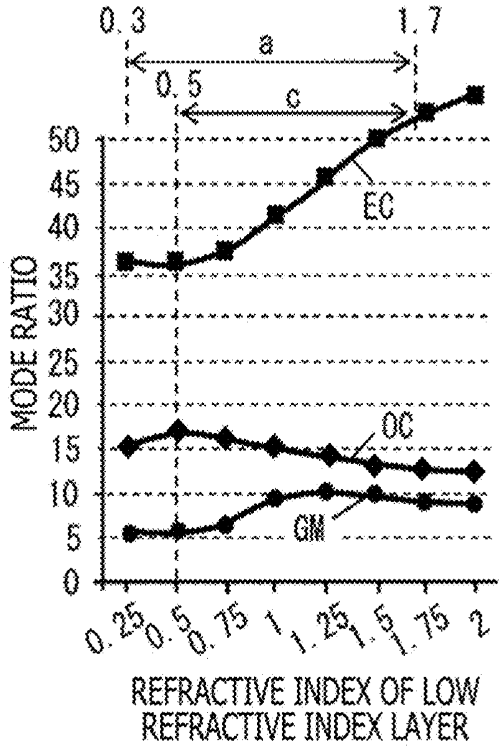

0.3
a
1.7
0.5
c
50
45
40
35
30
25
20
15
10
5
0
MODE RATIO
EC
OC
GM
0.25 0.5 0.75 1 1.25 1.5 1.75 2
REFRACTIVE INDEX OF LOW REFRACTIVE INDEX LAYER

FIG. 5

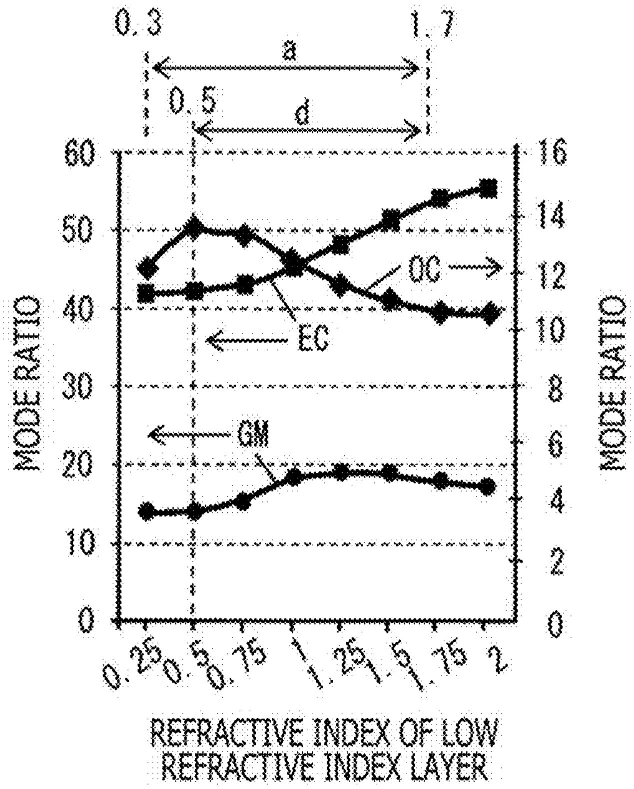


FIG. 6A

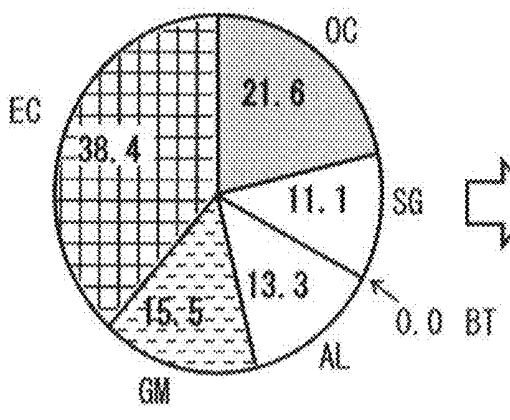


FIG. 6B

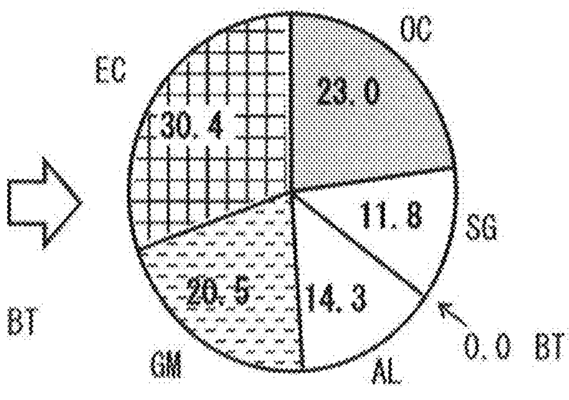


FIG. 7

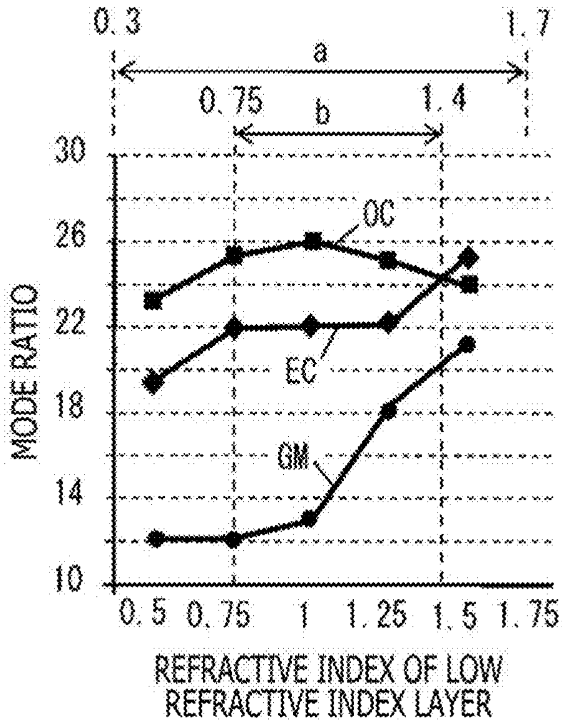

0.3
1.7
a
0.75
b
1.4
30
26
22
18
14
10
OC
EC
GM
MODE RATIO
0.5 0.75 1 1.25 1.5 1.75
REFRACTIVE INDEX OF LOW REFRACTIVE INDEX LAYER

FIG. 8

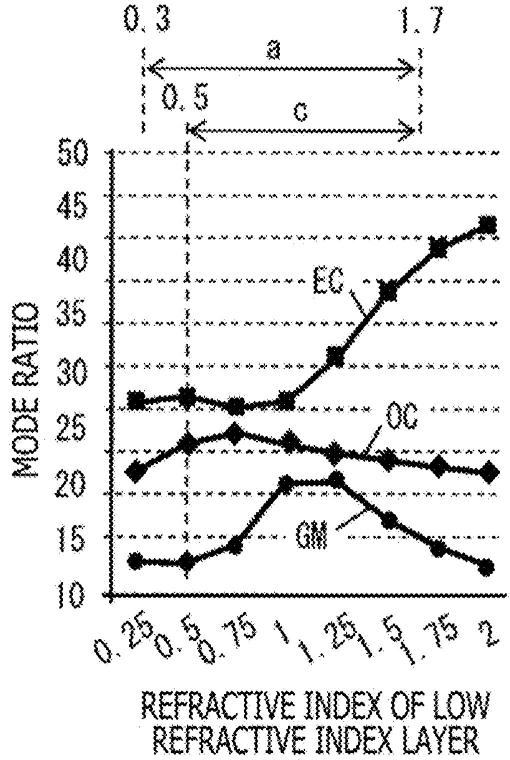

0.3
1.7
a
0.5
c
50
45
40
35
30
25
20
15
10
EC
OC
GM
MODE RATIO
0.25 0.5 0.75 1 1.25 1.5 1.75 2
REFRACTIVE INDEX OF LOW REFRACTIVE INDEX LAYER

FIG. 9

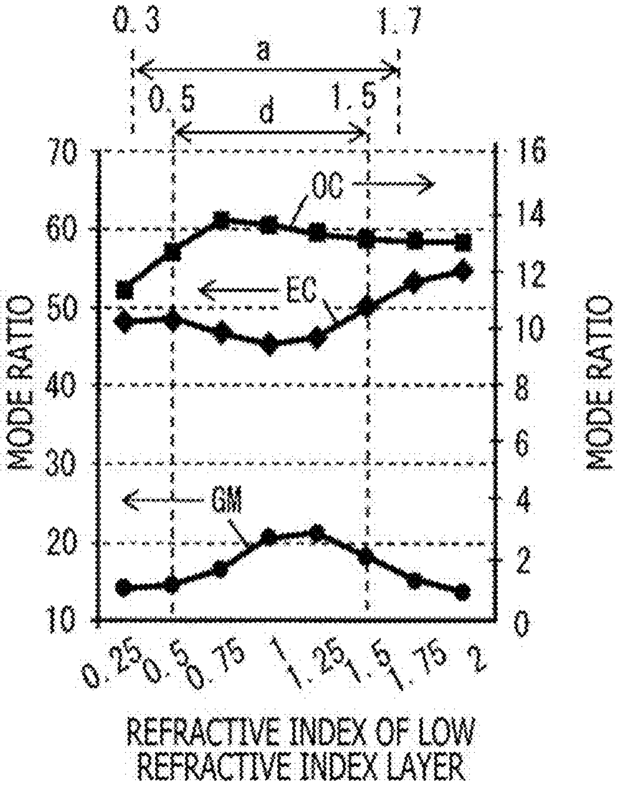

0.3
1.7
a
0.5
d
1.5
70
60
50
40
30
20
10
16
14
12
10
8
6
4
2
0
OC
EC
GM
MODE RATIO
MODE RATIO
0.25
0.5
0.75
1
1.25
1.5
1.75
2
REFRACTIVE INDEX OF LOW REFRACTIVE INDEX LAYER

FIG. 10

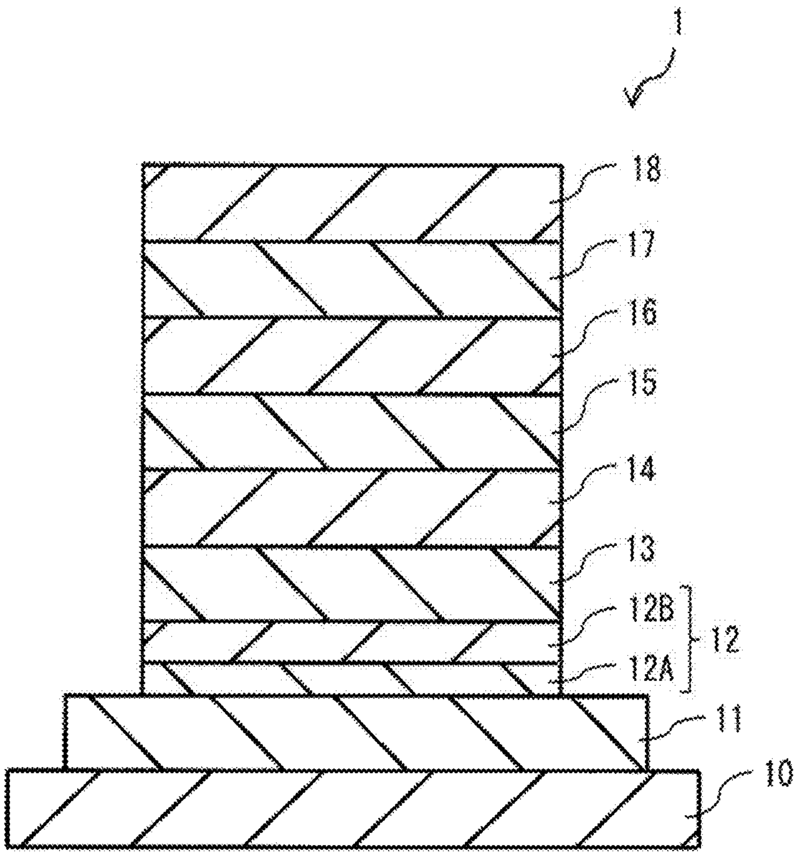


FIG. 11

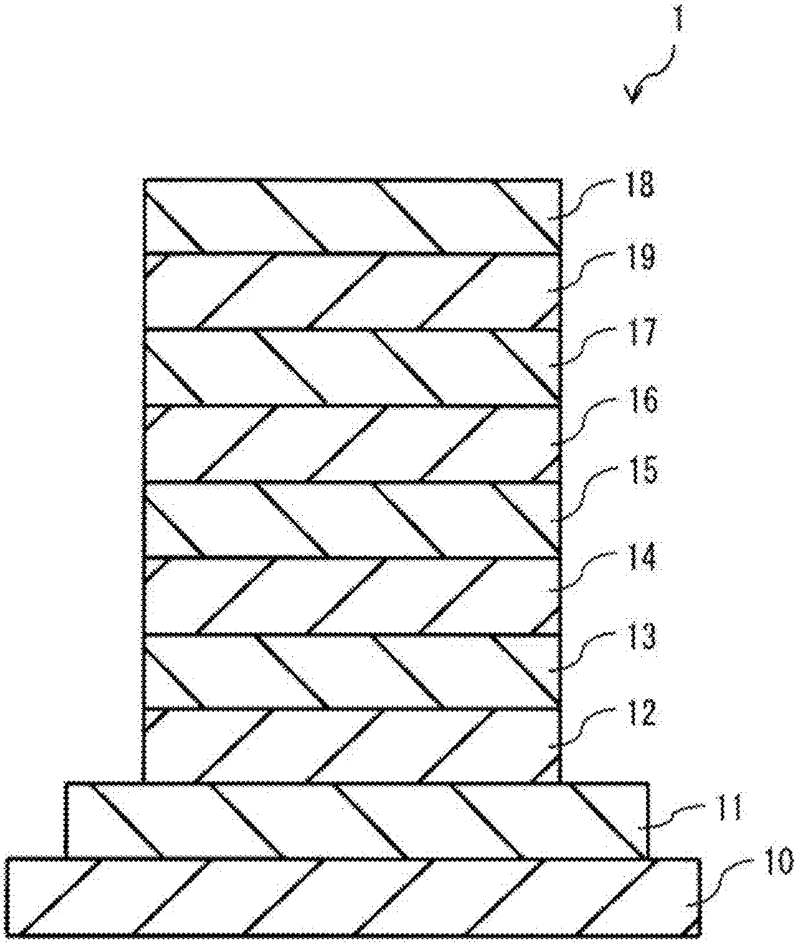


FIG.12

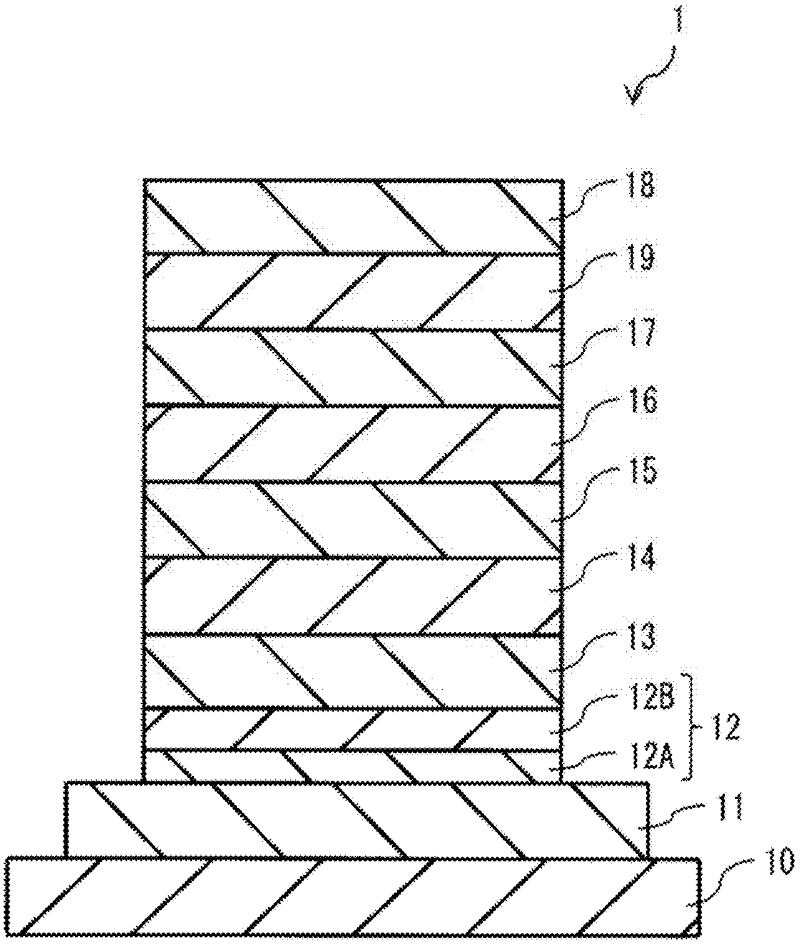


FIG.13

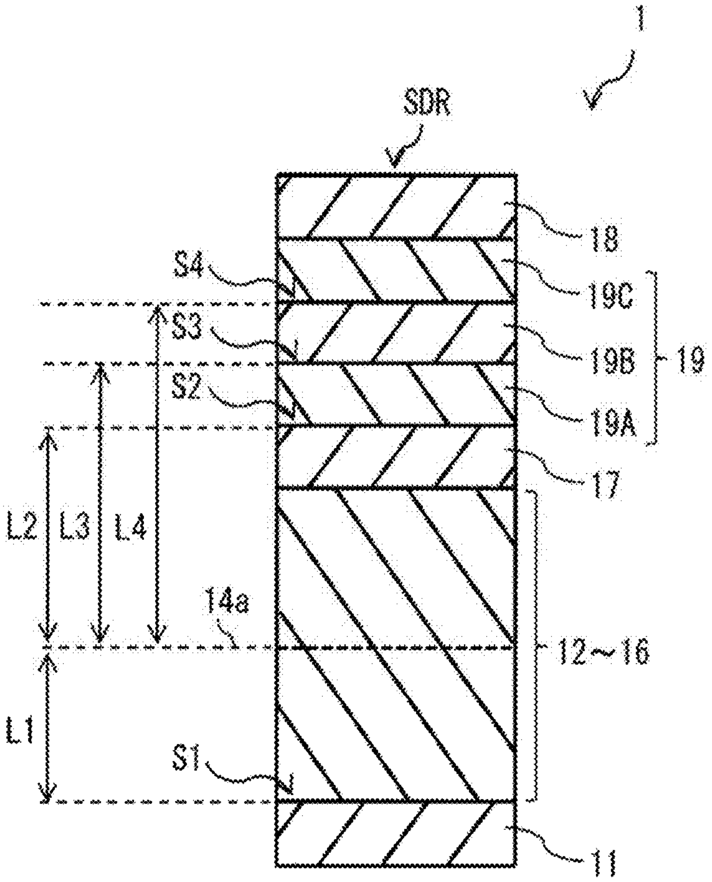


FIG. 14

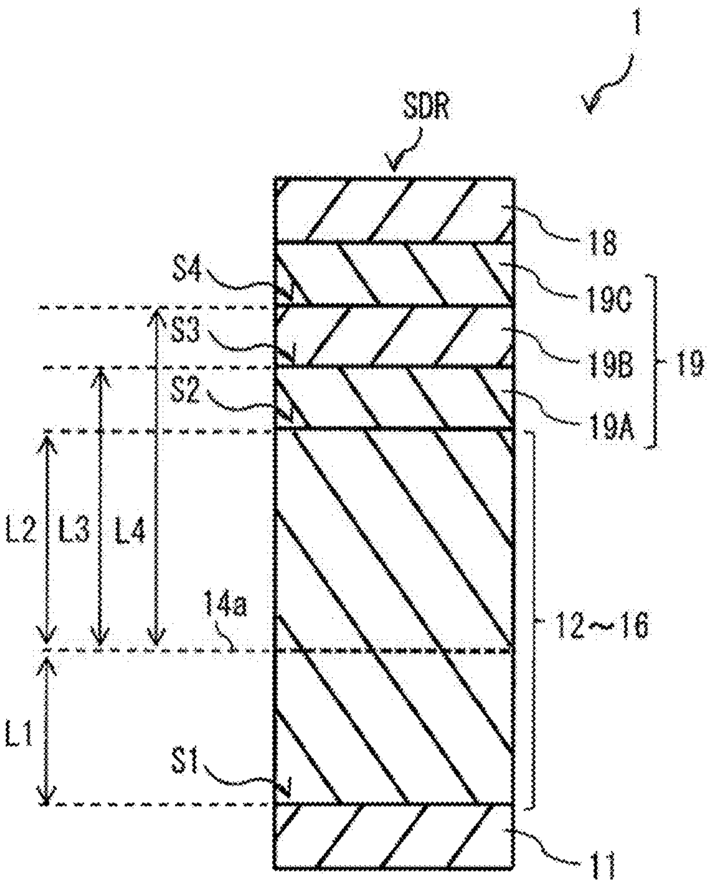


FIG.15

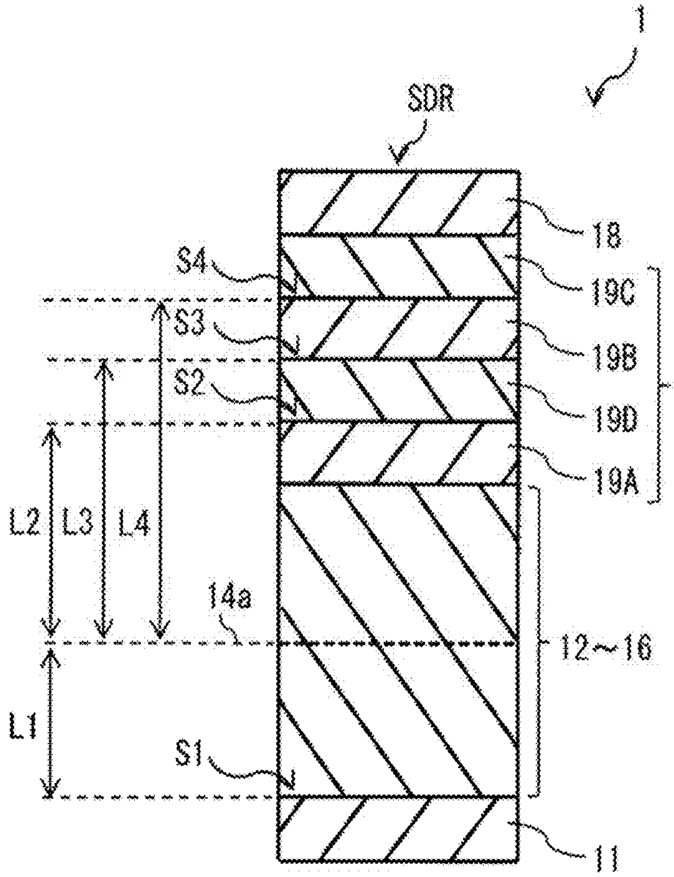

1
SDR
18
S4
19C
S3
19B
S2
19D
19
19A
L2
L3
L4
14a
12~16
L1
S1
11

FIG.16

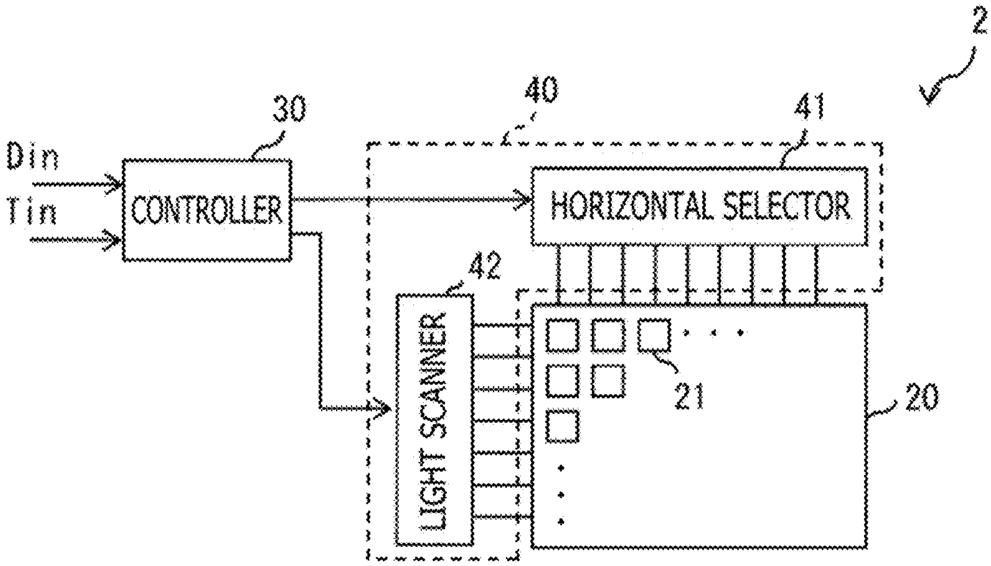

2
40
41
30
Din
Tin
CONTROLLER
HORIZONTAL SELECTOR
42
LIGHT SCANNER
21
20

FIG. 17

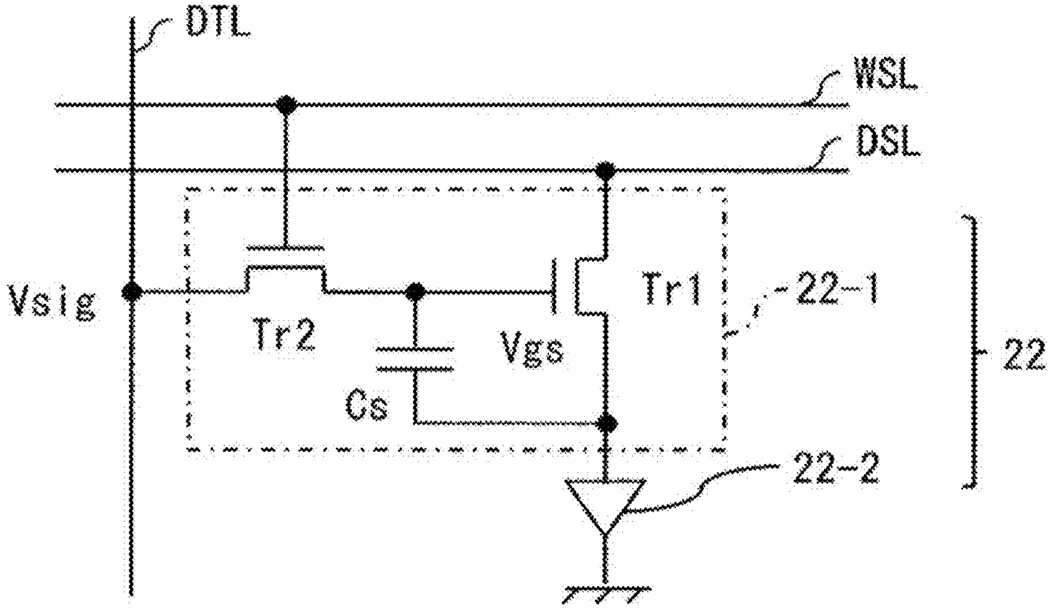


FIG.18

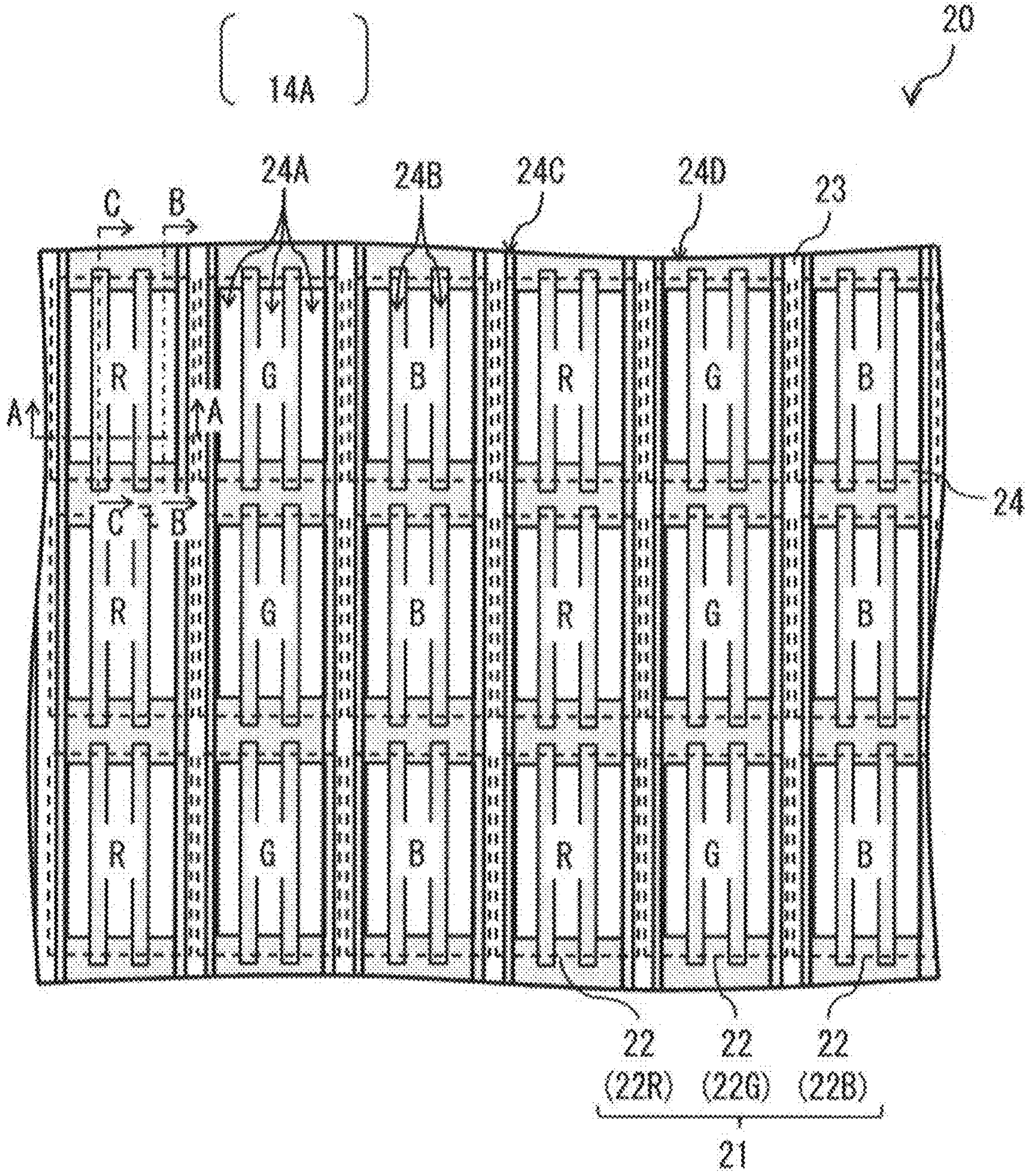

14A
20
24A
24B
24C
24D
23
C
B
A
A
C
B
R
G
B
R
G
B
24
22
(22R)
22
(22G)
22
(22B)
21

FIG.19

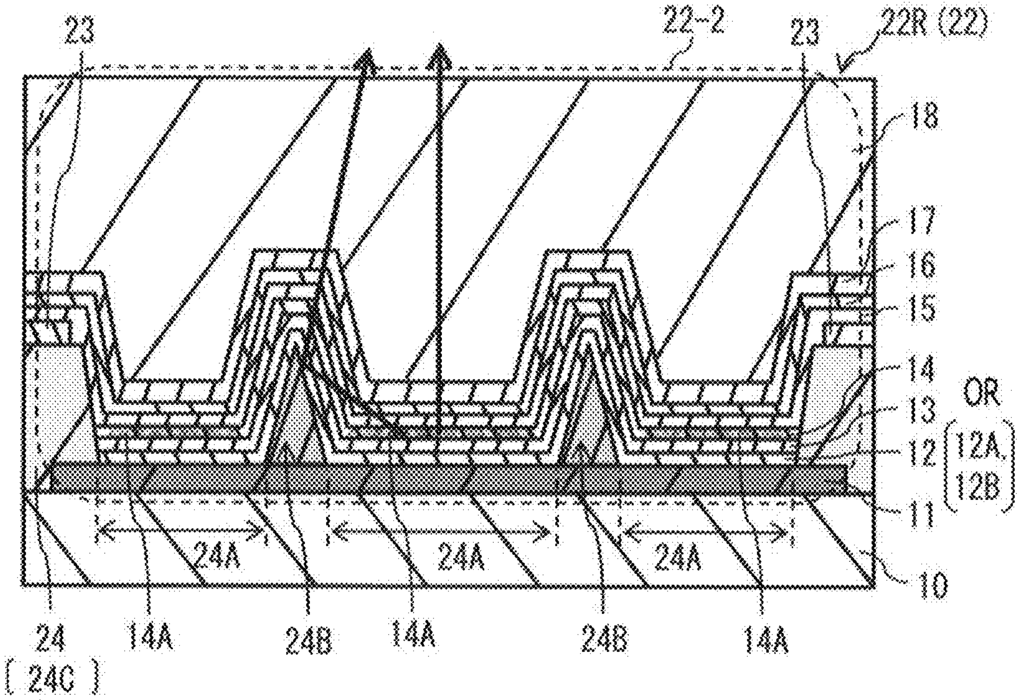

23
22-2
23
22R (22)
18
17
16
15
14
OR
13
12
12A,
12B
11
24A
24A
24A
10
24
24C
14A
24B
14A
24B
14A

FIG.20

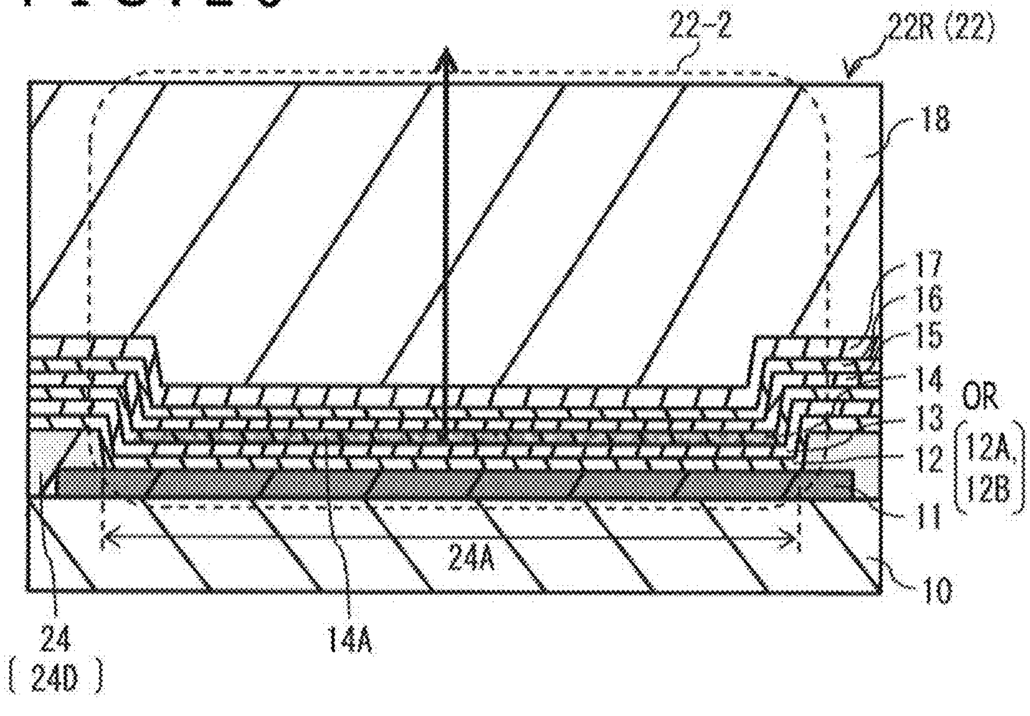

22-2
22R (22)
18
17
16
15
14
OR
13
12
12A,
12B
11
24A
10
24
24D
14A

FIG.21

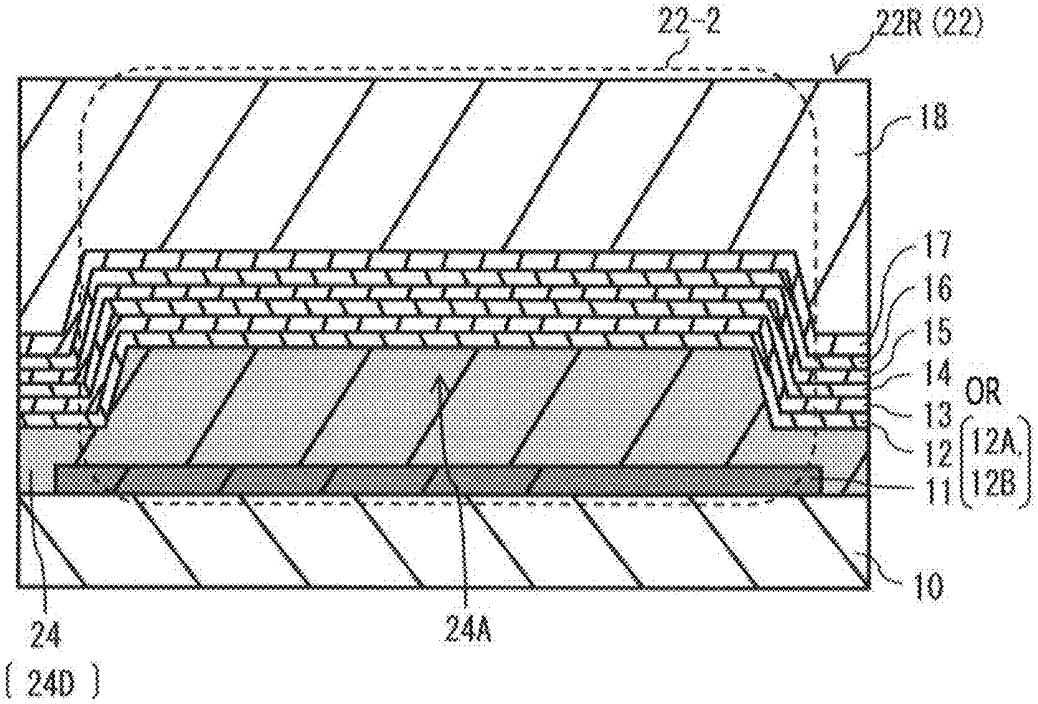
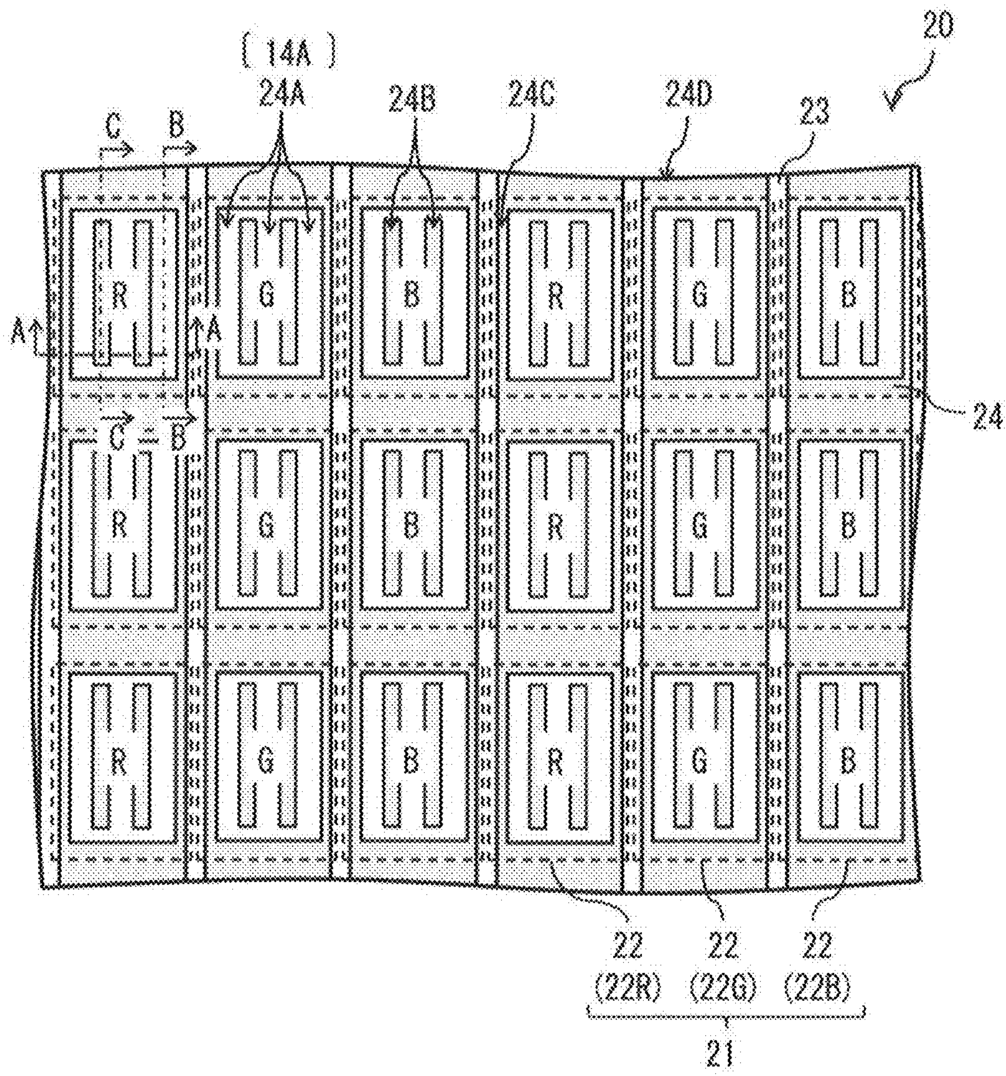


FIG.22



(14A)
24A
24B
24C
24D
23
20
C
B
A
A
C
B
R
G
B
R
G
B
R
G
B
R
G
B
R
G
B
R
G
B
24
22
(22R)
22
(22G)
22
(22B)
21

FIG. 23

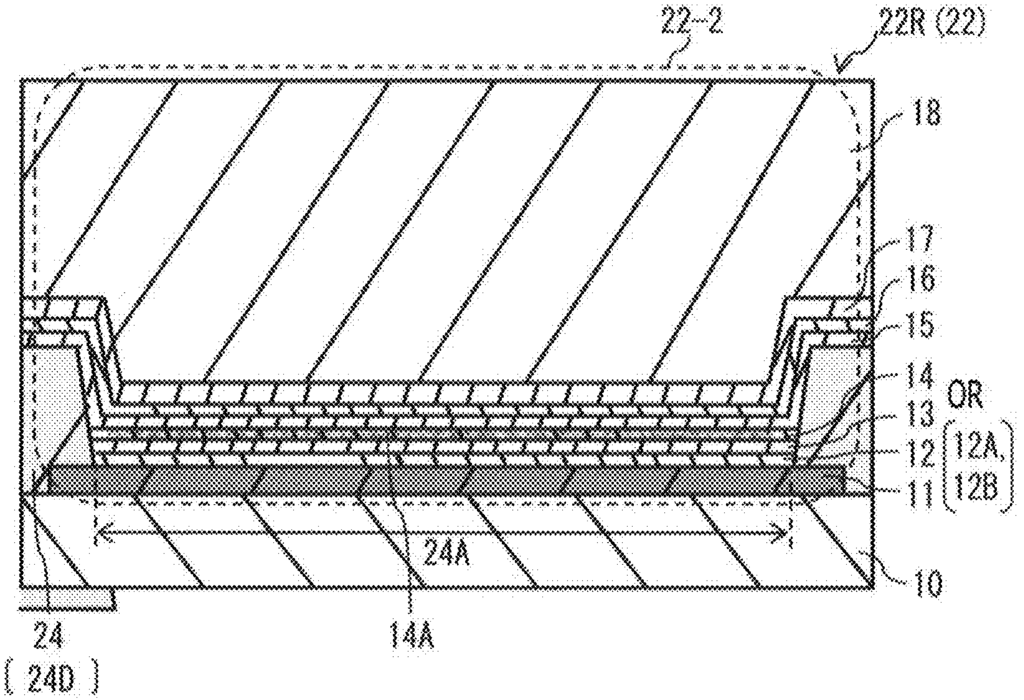

22-2
22R (22)
18
17
16
15
14
OR
13
12
12A,
12B
11
24A
10
24
(24D)
14A

FIG. 24

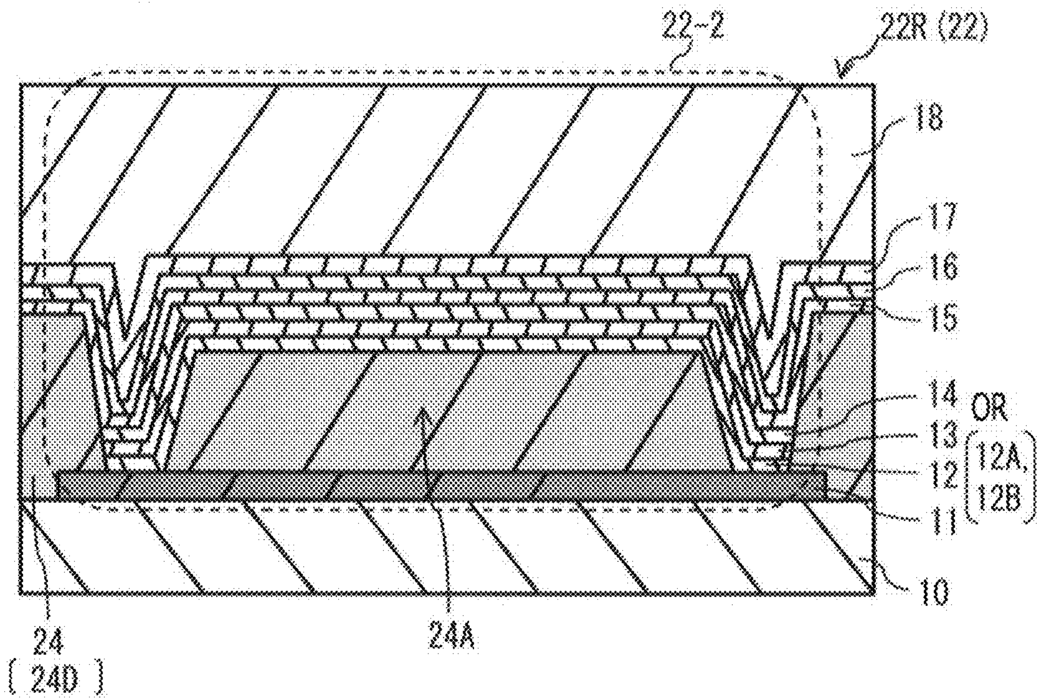
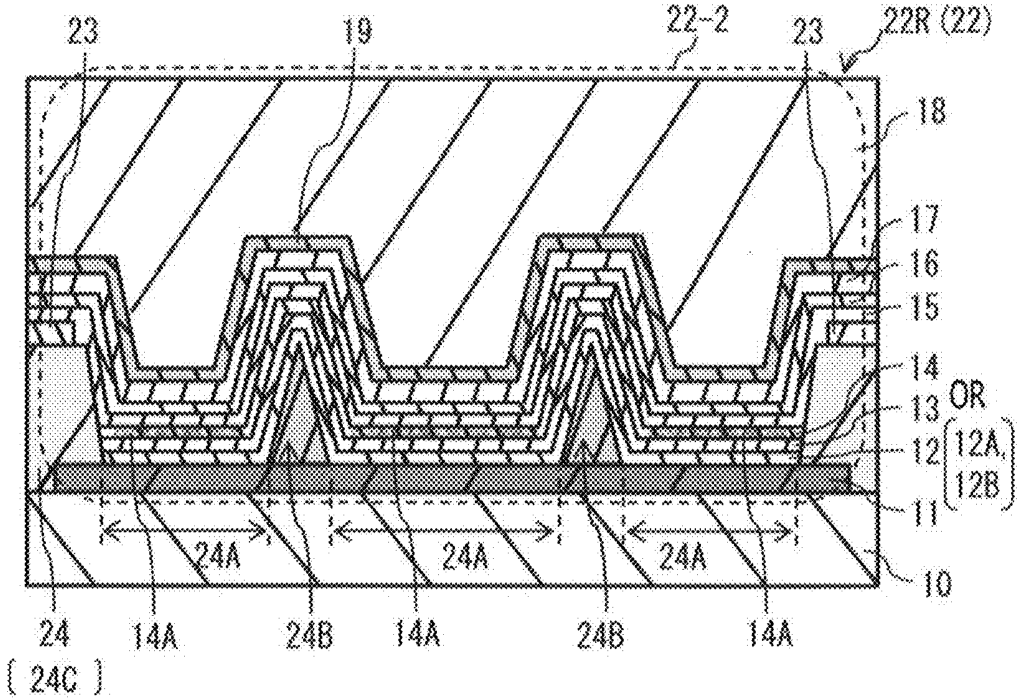
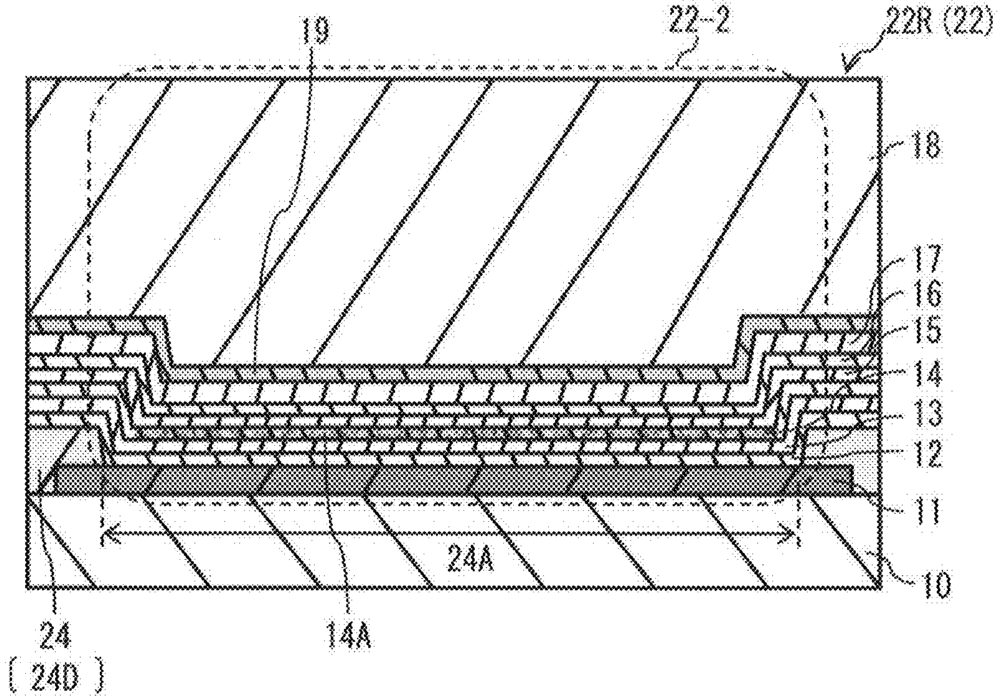

22-2
22R (22)
18
17
16
15
14
OR
13
12
12A,
12B
11
10
24
(24D)
24A

FIG. 25



23
19
22-2
23
22R (22)
18
17
16
15
14
OR
13
12
12A,
12B
11
10
24A
24A
24A
24
(24C)
14A
24B
14A
24B
14A

FIG. 26



19
22-2
22R (22)
18
17
16
15
14
13
12
11
10
24A
24
(24D)
14A

FIG.27

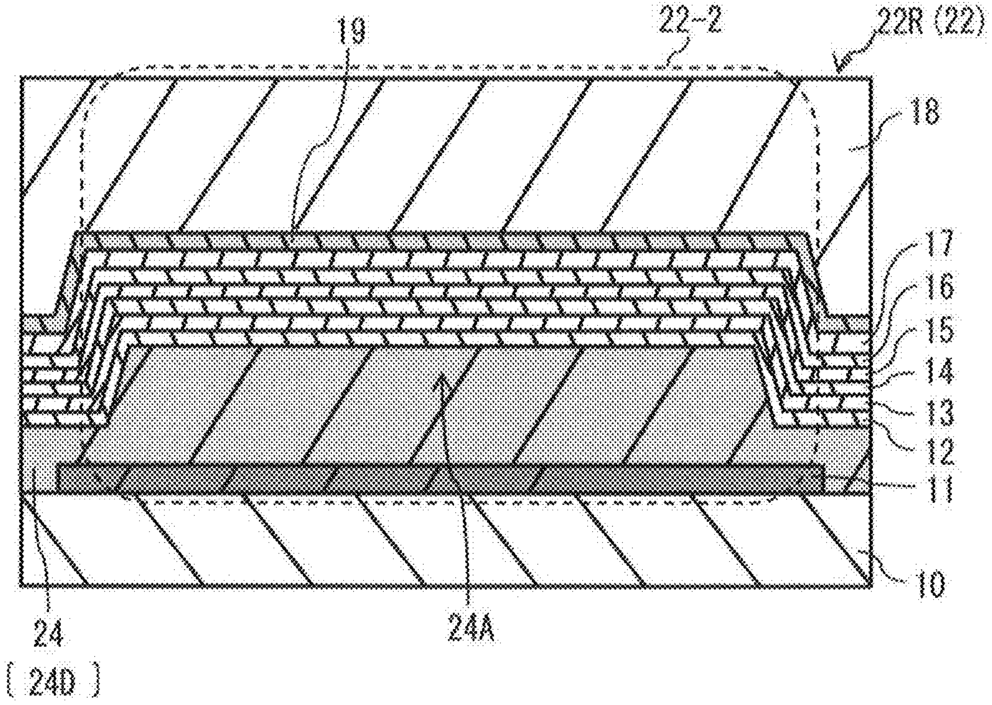


FIG.28

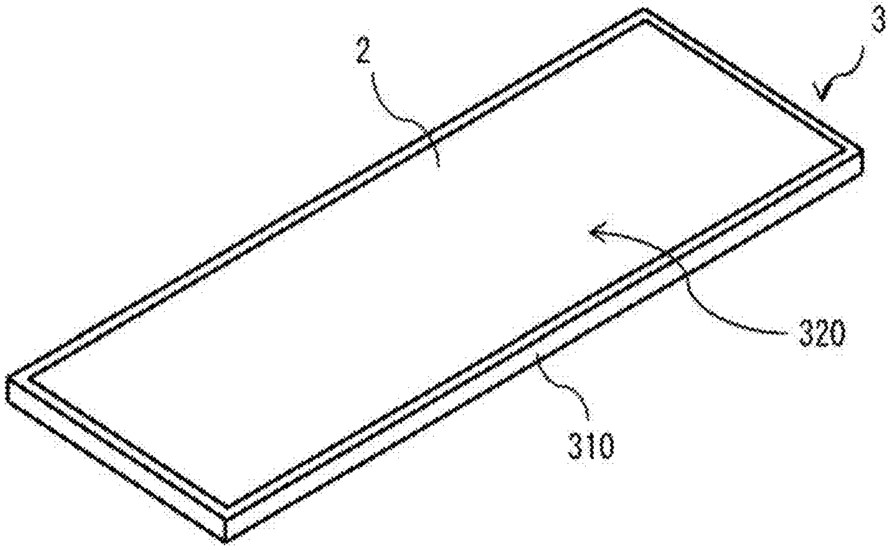
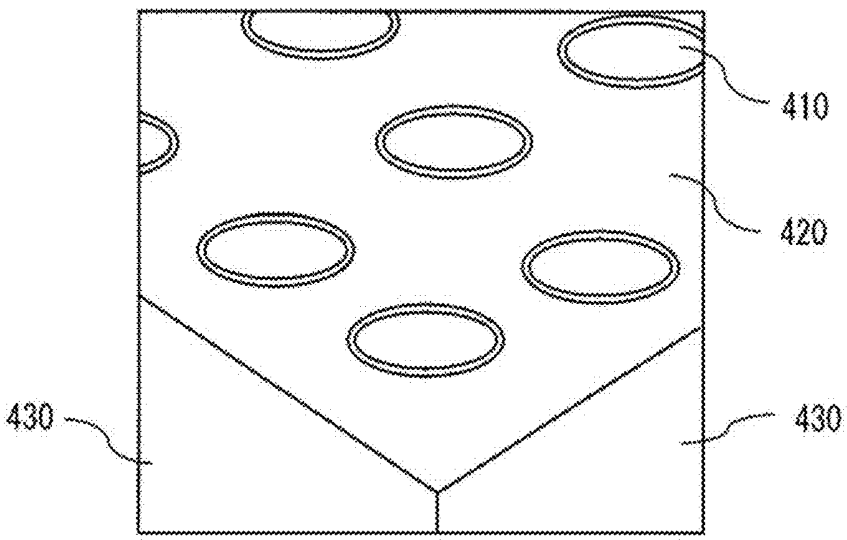


FIG.29



ORGANIC ELECTROLUMINESCENCE ELEMENT, ORGANIC ELECTROLUMINESCENCE PANEL AND ELECTRONIC APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to JP 2018-175874, filed on Sep. 20, 2018, and JP 2019-091166, filed on May 14, 2019, the entire contents of each are incorporated herein by reference.

BACKGROUND

[0002] The present disclosure relates to an organic electroluminescence element, an organic electroluminescence panel and an electronic apparatus.

[0003] As an organic electroluminescence device (organic electroluminescence display) using organic electroluminescence elements, a variety of ones have been proposed (see, for example, JP 2017-072812A).

SUMMARY

[0004] Meanwhile, in an organic electroluminescence device, in general, it is demanded to enhance the light extraction efficiency of organic electroluminescence elements. Therefore, it is desirable to provide an organic electroluminescence element capable of enhancing light extraction efficiency, and an organic electroluminescence panel and an electronic apparatus that include such organic electroluminescence elements.

[0005] According to an embodiment of the present disclosure, there is provided an organic electroluminescence element including an anode, a light emitting layer and a cathode in this order, and a low refractive index layer lower in refractive index than the light emitting layer at at least one of a position between the light emitting layer and the cathode and a position between the anode and the light emitting layer.

[0006] According to another embodiment of the present disclosure, there is provided an organic electroluminescence panel that includes a plurality of pixels. Each of the pixels has the above-mentioned organic electroluminescence element.

[0007] According to a further embodiment of the present disclosure, there is provided an electronic apparatus including the above-mentioned organic electroluminescence panel, and a driving circuit that drives the organic electroluminescence panel.

[0008] In the organic electroluminescence element, the organic electroluminescence panel and the electronic apparatus according to the embodiments of the present disclosure, the low refractive index layer lower in refractive index than the light emitting layer is provided at at least one of a position between the light emitting layer and the cathode and a position between the anode and the light emitting layer. This ensures that to the light going from the light emitting layer toward the low refractive index layer, the critical angle at the interface of the low refractive index layer is reduced. Therefore, the proportion in which the light going from the light emitting layer toward the low refractive index layer is reflected at the interface of the low refractive index layer is enhanced as compared to the case where the low refractive index layer is not provided. As a result, the proportion of evanescent deactivation due, for example, to surface plasmon at the anode and in the vicinity of the anode (evanescent mode) is lowered, and, therefore, the proportions of an external release mode and a waveguide mode are increased.

[0009] In accordance with the organic electroluminescence element, the organic electroluminescence panel and the electronic apparatus of the embodiments of the present disclosure, the low refractive index layer lower in refractive index than the light emitting layer is provided at at least one of a position between the light emitting layer and the cathode and a position between the anode and the light emitting layer, and, therefore, the proportions of the external release mode and the waveguide mode can be increased. As a result, light extraction efficiency can be enhanced. Note that the effects of the present disclosure are not limited to the effect described here, and the present disclosure may have any of the effects described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a figure depicting a sectional configuration example of an organic electroluminescence element according to a first embodiment of the present disclosure;

[0011] FIG. **2**A depicts an example of mode ratio of propagation mode of energy generated in an organic electroluminescence element according to a comparative example, and FIG. **2**B depicts a configuration example of propagation mode of energy generated in an organic electroluminescence element according to a working example;

[0012] FIG. **3** depicts an example of the relation between refractive index of a low refractive index layer and mode ratio of propagation mode, in an organic electroluminescence element that emits red light;

[0013] FIG. **4** depicts an example of the relation between refractive index of a low refractive index layer and mode ratio of propagation mode, in an organic electroluminescence element that emits green light;

[0014] FIG. **5** depicts an example of the relation between refractive index of a low refractive index layer and mode ratio of propagation mode, in an organic electroluminescence element that emits blue light;

[0015] FIG. **6**A depicts an example of mode ratio of propagation mode of energy generated in an organic electroluminescence element according to a comparative example, and FIG. **6**B depicts a configuration example of propagation mode of energy generated in an organic electroluminescence element according to a working example;

[0016] FIG. **7** depicts an example of the relation between refractive index of a low refractive index layer and mode ratio of propagation mode, in an organic electroluminescence element that emits red light;

[0017] FIG. **8** depicts an example of the relation between refractive index of a low refractive index layer and mode ratio of propagation mode, in an organic electroluminescence element that emits green light;

[0018] FIG. **9** depicts an example of the relation between refractive index of a low refractive index layer and mode ratio of propagation mode, in an organic electroluminescence element that emits blue light;

[0019] FIG. **10** is a figure depicting a modification of the sectional configuration of the organic electroluminescence element of FIG. **1**;

[0020] FIG. **11** is a figure depicting a modification of the sectional configuration of the organic electroluminescence element of FIG. **1**;

[0021] FIG. **12** is a figure depicting a modification of the sectional configuration of the organic electroluminescence element of FIG. **10**;

[0022] FIG. **13** is a figure depicting an example of the sectional configuration of the organic electroluminescence elements of FIGS. **11** and **12**;

[0023] FIG. **14** is a figure depicting an example of the sectional configuration of the organic electroluminescence elements of FIGS. **11** and **12**;

[0024] FIG. **15** is a figure depicting an example of the sectional configuration of the organic electroluminescence elements of FIGS. **11** and **12**;

[0025] FIG. **16** is a figure depicting a general configuration example of an organic electroluminescence device according to a second embodiment of the present disclosure;

[0026] FIG. **17** is a figure depicting a circuit configuration example of a sub-pixel included in each pixel of FIG. **16**;

[0027] FIG. **18** is a figure depicting a general configuration example of an organic electroluminescence panel of FIG. **16**;

[0028] FIG. **19** is a figure depicting a sectional configuration example, along line A-A, of the organic electroluminescence panel of FIG. **18**;

[0029] FIG. **20** is a figure depicting a sectional configuration example, along line B-B, of the organic electroluminescence panel of FIG. **18**;

[0030] FIG. **21** is a figure depicting a sectional configuration example, along line C-C, of the organic electroluminescence panel of FIG. **18**;

[0031] FIG. **22** is a figure depicting a modification of the general configuration of the organic electroluminescence panel of FIG. **16**;

[0032] FIG. **23** is a figure depicting a sectional configuration example, along line B-B, of the organic electroluminescence panel of FIG. **22**;

[0033] FIG. **24** is a figure depicting a sectional configuration example, along line C-C, of the organic electroluminescence panel of FIG. **22**;

[0034] FIG. **25** is a figure depicting a modification of the sectional configuration, along line A-A, of the organic electroluminescence panel of FIG. **18**;

[0035] FIG. **26** is a figure depicting a modification of the sectional configuration, along line B-B, of the organic electroluminescence panel of FIG. **18**;

[0036] FIG. **27** is a figure depicting a modification of the sectional configuration, along line C-C, of the organic electroluminescence panel of FIG. **18**;

[0037] FIG. **28** is a figure depicting on an oblique view basis an example of external appearance of an electronic apparatus including an organic electroluminescence device of the present disclosure; and

[0038] FIG. **29** is a figure depicting on an oblique view basis an example of external appearance of an illumination device including an organic electroluminescence element of the present disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0039] Embodiments of the present disclosure will be described in detail below, referring to the drawings. The embodiments described below are preferable specific examples of the present disclosure. Therefore, the numerical values, shapes, materials, components, layout positions and connection forms of the components, and the like indicated in the following embodiments are mere examples and are not limitative of the present disclosure. Accordingly, those of the components in the following embodiments which are not described in the independent claims describing the broadest concept of the present disclosure are described as arbitrary components. Note that the drawings are schematic figures, which are not necessarily drawn strictly. In addition, in the drawings, substantially the same configurations are denoted by the same reference signs, and repeated descriptions thereof will be omitted or simplified. Note that the descriptions will be made in the following order.

[0040] 1. First Embodiment (Organic Electroluminescence Element)

[0041] Example in which low refractive index layer is provided between light emitting layer and cathode

[0042] 2. Modifications of First Embodiment (Organic Electroluminescence Element)

[0043] Modification A: Example in which low refractive index layer is provided between anode and light emitting layer

[0044] Modification B: Example in which hole injection layer is configured as stacked body

[0045] Modification C: Example in which light distribution control layer is provided over cathode

[0046] 3. Second Embodiment (Organic Electroluminescence Panel and Organic Electroluminescence Device)

[0047] Examples in which organic electroluminescence elements according to first embodiment, modification A and modification B are respectively provided

[0048] 4. Modification of Second Embodiment (Organic Electroluminescence Panel and Organic Electroluminescence Device)

[0049] Example in which organic electroluminescence element according to modification C is provided

[0050] 5. Application Examples (Electronic Apparatus and Illumination Device)

1. FIRST EMBODIMENT

[Configuration]

[0051] FIG. **1** depicts an example of a sectional configuration of an organic electroluminescence element **1** according to a first embodiment of the present disclosure. The organic electroluminescence element **1** is provided, for example, over a substrate **10**. The organic electroluminescence element **1** includes, for example, a light emitting layer **14**, and an anode **11** and a cathode **17** which are disposed such as to sandwich the light emitting layer **14** therebetween. The organic electroluminescence element **1** further includes, for example, a hole injection layer **12** and a hole transport layer **13**, between the anode **11** and the light emitting layer **14**, in this order from the anode **11** side. The organic electroluminescence element **1** further includes, for example, an electron transport layer **15** and an electron injection layer **16**, between the light emitting layer **14** and the cathode **17**, in this order from the light emitting layer **14** side. Note that at least one of the hole injection layer **12** and the hole transport layer **13** may be omitted.

[0052] Either one of the electron transport layer **15** and the electron injection layer **16** corresponds to a specific example of a "low refractive index layer" in the present disclosure. Hereinafter, that one of the electron transport layer **15** and the electron injection layer **16** which corresponds to the specific example of the "low refractive index layer" in the present disclosure will be referred to as the low refractive index layer. Note that that layer of the electron transport layer **15** and the electron injection layer **16** which does not correspond to the specific example of the “low refractive index layer” in the present disclosure may be omitted.

[0053] The organic electroluminescence element **1** further includes, for example, a sealing layer **18** over the cathode **17**. The organic electroluminescence element **1** has an element structure configured to include, for example, the anode **11**, the hole injection layer **12**, the hole transport layer **13**, the light emitting layer **14**, the electron transport layer **15**, the electron injection layer **16**, the cathode **17** and the sealing layer **18** in this order from the substrate **10** side. The organic electroluminescence element **1** may further include other functional layers.

[0054] The substrate **10** is, for example, a light-transmitting substrate having a light-transmitting property such as a transparent substrate, and is, for example, a glass substrate formed of a glass material. Note that the substrate **10** is not limited to the glass substrate, but may be a light-transmitting resin substrate formed of a light-transmitting resin material such as a polycarbonate resin or an acrylic resin, or may be a thin film transistor (TFT) substrate which is a backplane of an organic EL display device.

[0055] The anode **11** is formed, for example, over the substrate **10**. The anode **11** is, for example, aluminum (Al), silver (Ag), or an aluminum or silver alloy or the like, or a reflective electrode having a reflecting property. Note that the anode **11** is not limited to a reflective electrode, but may be, for example, a light-transmitting transparent electrode. Examples of the material for the transparent electrode include transparent conductive materials such as indium tin oxide (ITO) or indium zinc oxide (IZO). The anode **11** may be a stacked body of a reflective electrode and a transparent electrode.

[0056] The hole injection layer **12** is a layer for enhancing hole injection efficiency. The hole injection layer **12** has a function of injecting holes, injected from the anode **11**, into the light emitting layer **14**. The hole injection layer **12** is configured using, for example, an oxide of silver (Ag), molybdenum (Mo), chromium (Cr), vanadium (V), tungsten (W), nickel (Ni), iridium (Ir) or the like, or a conductive polymer material such as PEDOT (a mixture of polythiophene and polystyrenesulfonic acid). The hole injection layer **12** may be composed of a single layer, or may have a stacked structure of a plurality of layers.

[0057] The hole transport layer **13** has a function of transporting holes, injected from the anode **11**, to the light emitting layer **14**. The hole transport layer **13** is configured using, for example, a material (hole transporting material) that has a function of transporting the holes, injected from the anode **11**, to the light emitting layer **14**. Examples of the hole transporting material include arylamine derivatives, triazole derivatives, oxadiazole derivatives, imidazole derivatives, polyaryalalkane derivatives, pyrazoline derivatives and pyrazolone derivatives, phenylenediamine derivatives, amino-substituted chalcone derivatives, oxazole derivatives, styrylanthracene derivatives, fluorenone derivatives, hydrozone derivatives, stilbene derivatives, butadiene derivatives, polystyrene derivatives, triphenylmethane derivatives, tetraphenylbenzine derivatives, and their combinations. The difference in highest occupied molecular orbital (HOMO) level between the materials of the hole injection layer **12** and the hole transport layer **13** is preferably not more than 0.5 eV, taking into account a hole injecting property.

[0058] The light emitting layer **14** is a layer in which holes injected from the anode **11** and electrons injected from the cathode **17** are re-combined with each other to produce excitons, thereby emitting light. The light emitting layer **14** is configured using, for example, an organic light emitting material. The light emitting layer **14** is, for example, a coating film, and is formed, for example, by applying a solution containing the organic light emitting material as solute, followed by drying. The light emitting layer **14** may be configured using a vapor deposited film.

[0059] The organic light emitting material as the raw material (material) for the light emitting layer **14** is, for example, a material obtained by combining a host material and a dopant material. The organic light emitting material as the raw material (material) for the light emitting layer **14** may be a dopant material alone. The host material is mainly in charge of the function of transporting carriers such as electrons or holes, while the dopant material is in charge of the function of emitting light. The host material and the dopant material are each not limited to one kind of material, and may each be a combination of two or more kinds of materials.

[0060] As the host material of the light emitting layer **14**, there is used, for example, an amine compound, a condensed polycyclic aromatic compound, or a heterocyclic compound. As the amine compound, there may be used, for example, monoamine derivatives, diamine derivatives, triamine derivatives, and tetraamine derivatives. Examples of the condensed polycyclic aromatic compound include anthracene derivatives, naphthalene derivatives, naphthacene derivatives, phenanthrene derivatives, chrysene derivatives, fluoranthene derivatives, triphenylene derivatives, pentacene derivatives, and perylene derivatives. Examples of the heterocyclic compound include carbazole derivatives, furan derivatives, pyridine derivatives, pyrimidine derivatives, triazine derivatives, imidazole derivatives, pyrazole derivatives, triazole derivatives, oxazole derivatives, oxadiazole derivatives, pyrrole derivatives, indole derivatives, azaindole derivatives, azacarbazole derivatives, pyrazoline derivatives, pyrazolone derivatives, and phthalocyanine derivatives.

[0061] In addition, as the dopant material of the light emitting layer **14**, there is used, for example, a pyrene derivative, a fluoranthene derivative, an arylacetylene derivative, a fluorene derivative, a perylene derivative, an oxadiazole derivative, an anthracene derivative, or a chrysene derivative. Besides, as a fluorescent dopant material of the light emitting layer **14**, a metal complex may be used. Examples of the metal complex include those having a metal atom of iridium (Ir), platinum (Pt), Osmium (Os), gold (Au), rhenium (Re), ruthenium (Ru) or the like and a ligand.

[0062] The electron transport layer **15** has a function of transporting electrons, injected from the cathode **17**, to the light emitting layer **14**. The electron transport layer **15** includes, for example, a material (electron transporting material) having a function of transporting the electrons, injected from the cathode **17**, to the light emitting layer **14**. The electron transport layer **15** is configured using, for example, a vapor deposited film or a sputtered film. The electron transport layer **15** preferably has a charge blocking function of restraining charges (in the present embodiment, holes) from penetrating from the light emitting layer **14** to the cathode **17**, a function of restraining quenching of an excited state of the light emitting layer **14**, or the like.

[0063] The above-mentioned electron transporting material is, for example, an aromatic heterocyclic compound having at least one hetero-atom in its molecule. Examples of the aromatic heterocyclic compound include those compounds which include a pyridine ring, a pyrimidine ring, a triazine ring, a benzimidazole ring, a phenanthroline ring, a quinazoline ring or the like in the skeleton thereof. The electron transporting material may be doped with a metal having an electron transporting property. In this case, the electron transport layer **15** is an organic electron transport layer containing a dopant metal. Where the metal having an electron transporting property is contained in the electron transport layer **15**, electron transporting property of the electron transport layer **15** can be enhanced thereby. Examples of the dopant metal contained in the electron transport layer **15** include transition metals such as ytterbium (Yb).

[0064] The electron injection layer **16** has a function of injecting electrons, injected from the cathode **17**, to the electron transport layer **15** and the light emitting layer **14**. The electron injection layer **16** is configured using, for example, a material (electron injecting material) having a function of accelerating the injection of electrons from the cathode **17** to the electron transport layer **15** and the light emitting layer **14**. The electron injecting material may be, for example, a material obtained by doping an organic material having an electron injecting property with a metal having an electron injecting property. The dopant metal contained in the electron injection layer **16** is, for example, the same metal as the dopant metal contained in the electron transport layer **15**.

[0065] The cathode **17** is, for example, a transparent electrode such as an ITO film. Note that the cathode **17** is not limited to the transparent electrode, but may be a reflective electrode having a light-reflecting property. As the material for the reflective electrode, there is used, for example, aluminum (Al), magnesium (Mg), silver (Ag), an aluminum-lithium alloy, or a magnesium-silver alloy. In the present embodiment, in the case where the substrate **10** and the anode **11** are reflective and the cathode **17** is light-transmitting, the organic electroluminescence element **1** is of a top emission structure in which light is released from the cathode **17** side. Note that in the present embodiment, in the case where the substrate **10** and the anode **11** are light-transmitting and the cathode **17** is reflective, the organic electroluminescence element **1** is of a bottom emission structure in which light is released from the substrate **10** side.

[0066] The sealing layer **18** is formed over the cathode **17**. The sealing layer **18** is formed, for example, in contact with an upper surface of the cathode **17**. The sealing layer **18** is formed, for example, of a resin material. Examples of the resin material to be used for the sealing layer **18** include epoxy resins and vinyl resins.

[0067] The low refractive index layer will be described below. The low refractive index layer is provided between the light emitting layer **14** and the cathode **17**, and is either one of the electron transport layer **15** and the electron injection layer **16**. In other words, the low refractive index layer has a function of injecting or transporting electrons, injected from the cathode **17**, into the light emitting layer **14**. Note that in the case where the electron injection layer **16** is configured using a single layer, the low refractive index layer may, for example, correspond to the whole part of the electron injection layer **16**. In the case where the electron injection layer **16** is configured using a stacked body of a plurality of layers, the low refractive index layer may, for example, correspond to the whole part of the electron injection layer **16** or may correspond to at least one layer included in the electron injection layer **16**. In addition, in the case where the electron transport layer **15** is configured using a single layer, the low refractive index layer may, for example, correspond to the whole part of the electron transport layer **15**. In the case where the electron transport layer **15** is configured using a stacked body of a plurality of layers, the low refractive index layer may, for example, correspond to the whole part of the electron transport layer **15** or may correspond to at least one layer included in the electron transport layer **15**.

[0068] The low refractive index layer is formed using a material that has a refractive index different from those of the light emitting layer **14** and the cathode **17**. Specifically, the low refractive index layer has a refractive index higher than the refractive index of the cathode **17** and lower than the refractive index of the light emitting layer **14**. Here, in the case where the cathode **17** is configured using, for example, a metallic material having a refractive index of 0.3 and the light emitting layer **14** is configured using, for example, an organic material having a refractive index of 1.7, the low refractive index layer is configured using a material having a refractive index higher than 0.3 and lower than 1.7.

[0069] FIG. **2**A depicts an example of mode ratio of propagation mode of energy generated in an organic electroluminescence element according to a comparative example. FIG. **2**B depicts a configuration example of propagation mode of energy generated in an organic electroluminescence element according to a working example. In the working example, the refractive index of either one of the electron transport layer **15** and the electron injection layer **16** is higher than the refractive index of the cathode **17** and lower than the refractive index of the light emitting layer **14**. The other conditions in the comparative example and the working example are as follows. Note that in FIGS. **2**A and **2**B, OC indicates an external release mode, SG indicates a substrate mode, BT indicates a mode (leakage mode) of leakage to the side opposite to the sealing layer **18** (namely, to the substrate **10** side), AL indicates a mode (loss mode) of generation of loss due to absorption in the organic electroluminescence element, GM indicates a waveguide mode, and EC indicates an evanescent mode.

[0070] In FIGS. **2**A and **2**B are indicated simulation results for an organic electroluminescence element having a microcavity structure in which secondary interference (second cavity) is generated and the light emission position is on the cathode side. Here, in the comparative example, the anode was configured using a material having a thickness of 200 nm and a refractive index of 0.7, the hole injection layer was configured using a material having a thickness of 10 nm and a refractive index of 1.7, the hole transport layer was configured using a material having a thickness of 180 nm and a refractive index of 1.7, and the light emitting layer **14** was configured using a material having a thickness of 60 nm and a refractive index of 1.7.

[0071] In the comparative example, further, the electron transport layer was configured using a material having a thickness of 10 nm and a refractive index of 1.8, the electron injection layer was configured using a material having a thickness of 10 nm and a refractive index of 2.0, the cathode was configured using a material having a thickness of 15 nm and a refractive index of 0.3, and the sealing layer was configured using a material having a thickness of 5 μm and a refractive index of 1.8. On the other hand, in the working example, the anode **11** was configured using a material having a thickness of 200 nm and a refractive index of 0.7, the hole injection layer **12** was configured using a material having a thickness of 10 nm and a refractive index of 1.7, the hole transport layer **13** was configured using a material having a thickness of 180 nm and a refractive index of 1.7, and the light emitting layer **14** was configured using a material having a thickness of 60 nm and a refractive index of 1.7. In the working example, further, the electron transport layer **15** was configured using a material having a thickness of 10 nm and a refractive index of 1.8, the electron injection layer **16** was configured using a material having a thickness of 10 nm and a refractive index of 1.3, the cathode **17** was configured using a material having a thickness of 15 nm and a refractive index of 0.3, and the sealing layer **18** was configured using a material having a thickness of 5 μm and a refractive index of 1.8.

[0072] From FIGS. **2**A and **2**B, it is seen that provision of the low refractive index layer between the light emitting layer **14** and the cathode **17** causes transition of photon energy from an evanescent mode to a waveguide mode. In addition, it is also seen that the transition of photon energy from the evanescent mode to the waveguide mode is attended by an increase in the external release mode. Note that the photon energy having transited to the waveguide mode is reflected, for example, by a reflector structure described in a second embodiment, and can be emitted to the exterior as light build up toward the front direction.

[0073] Meanwhile, the provision of the low refractive index layer between the light emitting layer **14** and the cathode **17** means, to the light going from the light emitting layer **14** toward the low refractive index layer, that the critical angle at the interface of the low refractive index layer is decreased. Therefore, in the present embodiment and the working example, the proportion in which the light going from the light emitting layer **14** toward the low refractive index layer is reflected at the interface of the low refractive index layer is enhanced, as compared to the case where the low refractive index layer is not provided. As a result, the proportion of evanescent deactivation due, for example, to surface plasmon in the vicinity of the anode **11** is lowered, so that the external release mode and the waveguide mode are increased. In addition, there has been a report that the energy radiation distribution from excitons varies largely under the influences of the properties (dielectric constant, refractive index, etc.) of the ambient environment (materials) and that, for example, if a field of a high refractive index is present, energy is radiated toward the field. It is assumed that the proportions of transition to other modes are increased, also through such a phenomenon.

[0074] FIG. **3** depicts an example of the relation between the refractive index of the low refractive index layer and mode ratios of propagation modes, for an organic electroluminescence element **1** that emits red light. FIG. **4** depicts an example of the relation between the refractive index of the low refractive index layer and mode ratios of propagation modes, for an organic electroluminescence element **1** that emits green light. FIG. **5** depicts an example of the relation between the refractive index of the low refractive index layer and mode ratios of propagation modes, for an organic electroluminescence element **1** that emits blue light.

[0075] FIGS. **3** to **5** exemplify simulation results concerning the case where the organic electroluminescence element **1** has a microcavity structure in which secondary interference (second cavity) is generated and the light emission position is on the cathode **17** side. The refractive index of the low refractive index layer on the axis of abscissas depicted in FIGS. **3** to **5** indicates the refractive index of the electron injection layer **16**.

[0076] In FIG. **3**, the anode **11** was configured using a material having a thickness of 200 nm and a refractive index of 0.3, the hole injection layer **12** was configured using a low refractive index material in a thickness of 10 nm, the hole transport layer **13** was configured using a material having a thickness of 220 nm and a refractive index of 1.7, and the light emitting layer **14** was configured using a material having a thickness of 60 nm and a refractive index of 1.7. In addition, in FIG. **3**, the electron transport layer **15** was configured using a material having a thickness of 10 nm and a refractive index of 1.8, the electron injection layer **16** was configured in a thickness of 10 nm, the cathode **17** was configured using a material having a thickness of 15 nm and a refractive index of 0.3, and the sealing layer **18** was configured using a material having a thickness of 5 μm and a refractive index of 1.8.

[0077] In FIG. **4**, the anode **11** was configured using a material having a thickness of 200 nm and a refractive index of 0.3, the hole injection layer **12** was configured using a low refractive index material in a thickness of 10 nm, the hole transport layer **13** was configured using a material having a thickness of 180 nm and a refractive index of 1.7, and the light emitting layer **14** was configured using a material having a thickness of 60 nm and a refractive index of 1.7. In addition, in FIG. **4**, the electron transport layer **15** was configured using a material having a thickness of 10 nm and a refractive index of 1.8, the electron injection layer **16** was configured in a thickness of 10 nm, the cathode **17** was configured using a material having a thickness of 15 nm and a refractive index of 0.3, and the sealing layer **18** was configured using a material having a thickness of 5 μm and a refractive index of 1.8.

[0078] In FIG. **5**, the anode **11** was configured using a material having a thickness of 200 nm and a refractive index of 0.3, the hole injection layer **12** was configured using a low refractive index material in a thickness of 10 nm, the hole transport layer **13** was configured using a material having a thickness of 140 nm and a refractive index of 1.7, and the light emitting layer **14** was configured using a material having a thickness of 40 nm and a refractive index of 1.7. Besides, in FIG. **5**, the electron transport layer **15** was configured using a material having a thickness of 10 nm and a refractive index of 1.8, the electron injection layer **16** was configured in a thickness of 10 nm, the cathode **17** was configured using a material having a thickness of 15 nm and a refractive index of 0.3, and the sealing layer **18** was configured using a material having a thickness of 5 μm and a refractive index of 1.8.

[0079] As aforementioned, in the organic electroluminescence elements **1** that emit light in respective colors, the refractive index of the low refractive index layer is preferably higher than the refractive index (for example, 0.3) of the cathode **17** and lower than the refractive index (for example, 1.7) of the light emitting layer **14**. In the organic electroluminescence element **1** that emits red light, the refractive index of the low refractive index layer is preferably not less than 0.5, at which the proportion of the waveguide mode increases. Therefore, in the organic electroluminescence element **1** that emits red light, the refractive index of the low refractive index layer is preferably a value in the range "a" in FIG. **3**, more preferably a value in the range "b" in FIG. **3**.

[0080] In the organic electroluminescence element **1** that emits green light, the refractive index of the low refractive index layer is preferably not less than 0.5, at which the proportion of the waveguide mode increases. Therefore, in the organic electroluminescence element **1** that emits green light, the refractive index of the low refractive index layer is preferably a value in the range "a" in FIG. **4**, more preferably a value in the range "c" in FIG. **4**.

[0081] In the organic electroluminescence element **1** that emits blue light, the refractive index of the low refractive index layer is preferably not less than 0.5, at which the proportion of the waveguide mode increases. Therefore, in the organic electroluminescence element **1** that emits blue light, the refractive index of the low refractive index layer is preferably a value in the range "a" in FIG. **5**, more preferably a value in the range "d" in FIG. **5**.

[Effect]

[0082] Effects of the organic electroluminescence element **1** according to the present embodiment will be described below.

[0083] As an organic electroluminescence device using an organic electroluminescence element, a variety of ones have been proposed. The organic electroluminescence element is an element in which electrons and holes injected from a cathode and an anode re-combine with each other in a light emitting layer, to generate excitons, and the excitons release light when returning to a lower energy level or a ground state. Therefore, in the organic electroluminescence element, it is necessary to effectively inject the carriers and to effectively extract the light to the exterior.

[0084] Here, paying attention to hole injection, of carrier injection, it is important that the hole injection layer **12** injects holes into the light emitting layer **14** and has a function of lowering the proportion of generation of deactivation in which the energy of the excitons produced at the light emission center is lost in the vicinity of the anode **11**. In view of this, in the present embodiment, the low refractive index layer having a refractive index higher than the refractive index of the cathode **17** and lower than the refractive index of the light emitting layer **14** is provided between the light emitting layer **14** and the cathode **17**. This ensures that to the light going from the light emitting layer **14** toward the low refractive index layer, the critical angle at the interface of the low refractive index layer is reduced, and, therefore, the proportion in which the light going from the light emitting layer **14** toward the low refractive index layer is reflected at the interface of the low refractive index layer is enlarged, as compared to the case where the low refractive index layer is not provided. As a result, the proportion of evanescent deactivation of excitons due, for example, to surface plasmon in the vicinity of the anode **11** is lowered, and, therefore, the proportions of the external release mode and the waveguide mode are increased. Accordingly, the injection or transport of holes into the light emitting layer **14** can be promoted and light extraction efficiency can be enhanced, by the low refractive index layer.

[0085] In addition, in the present embodiment, in the case where the low refractive index layer is configured using a material having a refractive index of higher than 0.3 and lower than 1.7, to the light going from the light emitting layer **14** toward the low refractive index layer, the critical angle at the interface of the low refractive index layer is reduced, and, therefore, the proportion in which the light going from the light emitting layer **14** toward the low refractive index layer is reflected at the interface of the low refractive index layer is enlarged, as compared to the case where the low refractive index layer is not provided. As a result, the proportion of evanescent deactivation of excitons due, for example, to surface plasmon in the vicinity of the anode **11** is reduced, and, therefore, the proportions of the external release mode and the waveguide mode are increased. Accordingly, the injection or transport of holes into the light emitting layer **14** can be promoted and light extraction efficiency can be enhanced, by the low refractive index layer.

[0086] In addition, in the organic electroluminescence element **1** that emits red light according to the present embodiment, in the case where the refractive index of the low refractive index layer is 0.5 to 1.7, the proportion of the waveguide mode is enhanced. This ensures that the injection or transport of holes into the light emitting layer **14** can be promoted and light extraction efficiency can be enhanced.

[0087] Besides, in the organic electroluminescence element **1** that emits green light according to the present embodiment, in the case where the refractive index of the low refractive index layer is 0.5 to 1.7, the proportion of the waveguide mode is enhanced. This ensures that the injection or transport of holes into the light emitting layer **14** can be promoted and light extraction efficiency can be enhanced.

[0088] In addition, in the organic electroluminescence element **1** that emits blue light according to the present embodiment, in the case where the refractive index of the low refractive index layer is 0.5 to 1.7, the proportion of the waveguide mode is enhanced. This ensures that the injection or transport of holes into the light emitting layer **14** can be promoted and light extraction efficiency can be enhanced.

2. MODIFICATIONS OF FIRST EMBODIMENT

[0089] A modification of the organic electroluminescence element **1** according to the first embodiment will be described below.

[Modification A]

[0090] In the above embodiment, the low refractive index layer has been provided between the light emitting layer **14** and the cathode **17**. However, in the above embodiment, the low refractive index layer may be provided not between the light emitting layer **14** and the cathode **17** but between the anode **11** and the light emitting layer **14**. In addition, in the above embodiment, the low refractive index layer may be provided between the light emitting layer **14** and the cathode **17** and is also provided between the anode **11** and the light emitting layer **14**. Hereinafter, the low refractive index layer provided between the anode **11** and the light emitting layer **14** will be described.

[0091] The low refractive index layer is provided between the anode **11** and the light emitting layer **14**, and is either one of the hole injection layer **12** and the hole transport layer **13**. In other words, the low refractive index layer has a function of injecting or transporting holes, injected from the anode **11**, into the light emitting layer **14**. Note that in the case where the hole injection layer **12** is configured using a single layer, the low refractive index layer may correspond, for example, to the whole part of the hole injection layer **12**. In the case where the hole injection layer **12** is configured using a stacked body of a plurality of layers, the low refractive index layer may correspond, for example, to the whole part of the hole injection layer **12** or may correspond to at least one layer included in the hole injection layer **12**. In addition, in the case where the hole transport layer **13** is configured using a single layer, the low refractive index layer may correspond, for example, to the whole part of the hole transport layer **13**. In the case where the hole transport layer **13** is configured using a stacked body of a plurality of layers, the low refractive index layer may correspond, for example, to the whole part of the hole transport layer **13** or may correspond to at least one layer included in the hole transport layer **13**.

[0092] The low refractive index layer is formed using a material having a refractive index different from those of the anode **11** and the light emitting layer **14**. Specifically, the low refractive index layer has a refractive index higher than the refractive index of the anode **11** and lower than the refractive index of the light emitting layer **14**. Here, in the case where the anode **11** is configured using, for example, a metallic material having a refractive index of 0.3 and the light emitting layer **14** is configured using, for example, an organic material having a refractive index of 1.7, the low refractive index layer is configured using a material having a refractive index higher than 0.3 and lower than 1.7.

[0093] FIG. **6**A depicts an example of mode ratios of propagation modes of energy generated in an organic electroluminescence element according to a comparative example. FIG. **6**B depicts a configuration example of mode ratios of propagation modes of energy generated in an organic electroluminescence element according to a working example. In the comparative example, the refractive indexes of the hole injection layer **12** and the hole transport layer **13** are both equal to the refractive index of the light emitting layer **14**. On the other hand, in the working example, the refractive index of either one of the hole injection layer **12** and the hole transport layer **13** is higher than the refractive index of the anode **11** and lower than the refractive index of the light emitting layer **14**. The other conditions in the comparative example and the working example are as follows. Note that in FIGS. **6**A and **6**B, OC indicates an external release mode, SG indicates a substrate mode, BT indicates a mode (leakage mode) of leakage to the side opposite to the sealing layer **18** (namely, to the substrate **10** side), AL indicates a mode (loss mode) of generation of loss due to absorption in the organic electroluminescence element, GM indicates a waveguide mode, and EC indicates an evanescent mode.

[0094] In FIGS. **6**A and **6**B are indicated simulation results for an organic electroluminescence element having a microcavity structure in which secondary interference (second cavity) is generated and the light emission position is on the anode side. Here, in the comparative example, the anode was configured using a material having a thickness of 200 nm and a refractive index of 0.7, the hole injection layer was configured using a material having a thickness of 10 nm and a refractive index of 1.7, the hole transport layer was configured using a material having a thickness of 20 nm and a refractive index of 1.7, and the light emitting layer **14** was configured using a material having a thickness of 90 nm and a refractive index of 1.7.

[0095] In the comparative example, further, the electron transport layer was configured using a material having a thickness of 30 nm and a refractive index of 1.8, the electron injection layer was configured using a material having a thickness of 80 nm and a refractive index of 2.0, the cathode was configured using a material having a thickness of 15 nm and a refractive index of 0.3, and the sealing layer was configured using a material having a thickness of 5 μm and a refractive index of 1.8. On the other hand, in the working example, the anode **11** was configured using a material having a thickness of 200 nm and a refractive index of 0.7, the hole injection layer **12** was configured using a material having a thickness of 10 nm and a refractive index of 1.3, the hole transport layer **13** was configured using a material having a thickness of 20 nm and a refractive index of 1.7, and the light emitting layer **14** was configured using a material having a thickness of 90 nm and a refractive index of 1.7. In the working example, further, the electron transport layer **15** was configured using a material having a thickness of 30 nm and a refractive index of 1.8, the electron injection layer **16** was configured using a material having a thickness of 80 nm and a refractive index of 2.0, the cathode **17** was configured using a material having a thickness of 15 nm and a refractive index of 0.3, and the sealing layer **18** was configured using a material having a thickness of 5 μm and a refractive index of 1.8.

[0096] From FIGS. **6**A and **6**B, it is seen that the provision of the low refractive index layer between the anode **11** and the light emitting layer **14** causes transition of photon energy from the evanescent mode to the waveguide mode. In addition, it is also seen that the transition of the photon energy from the evanescent mode to the waveguide mode is attended by an increase in the external release mode. Note that the photon energy having transited to the waveguide mode is reflected, for example, by a reflector structure to be described in the second embodiment, and can be emitted to the exterior as light built up toward the front direction.

[0097] Meanwhile, the provision of the low refractive index layer between the anode **11** and the light emitting layer **14** means, to the light going from the light emitting layer **14** toward the low refractive index layer, that the critical angle at the interface of the low refractive index layer is decreased. Therefore, in the present embodiment and the working example, the proportion in which the light going from the light emitting layer **14** toward the low refractive index layer is reflected at the interface of the low refractive index layer is enhanced, as compared to the case where the low refractive index layer is not provided. As a result, the proportion of evanescent deactivation due, for example, to surface plasmon in the vicinity of the anode **11** is lowered, so that the external release mode and the waveguide mode are increased. In addition, there has been a report that the energy radiation distribution from excitons varies largely under the influences of the properties (dielectric constant, refractive index, etc.) of the ambient environment (materials) and that, for example, if a field of a high refractive index is present, energy is radiated toward the field. It is assumed that the proportions of transition to other modes are increased, also through such a phenomenon.

[0098] FIG. **7** depicts an example of the relation between the refractive index of the low refractive index layer and mode ratios of propagation modes, in an organic electroluminescence element **1** that emits red light. FIG. **8** depicts an example of the relation between the refractive index of the low refractive index layer and mode ratios of propagation modes, in an organic electroluminescence element **1** that emits green light. FIG. **9** depicts an example of the relation between the refractive index of the low refractive index layer and mode ratios of propagation modes, in an organic electroluminescence element **1** that emits blue light.

[0099] In FIGS. **7** to **9** are indicated simulation results in the case where the organic electroluminescence element **1** has a microcavity structure in which secondary interference (second cavity) is generated and the light emission position is on the anode **11** side. The refractive index of the low refractive index layer on the axis of abscissas depicted in FIGS. **7** to **9** indicates the refractive index of the hole injection layer **12**.

[0100] In FIG. **6**, the anode **11** was configured using a material having a thickness of 200 nm and a refractive index of 0.3, the hole injection layer **12** was configured using a low refractive index material in a thickness of 10 nm, the hole transport layer **13** was configured using a material having a thickness of 30 nm and a refractive index of 1.7, and the light emitting layer **14** was configured using a material having a thickness of 120 nm and a refractive index of 1.7. In addition, in FIG. **6**, the electron transport layer **15** was configured using a material having a thickness of 30 nm and a refractive index of 1.8, the electron injection layer **16** was configured using a material having a thickness of 80 nm and a refractive index of 2.0, the cathode **17** was configured using a material having a thickness of 15 nm and a refractive index of 0.3, and the sealing layer **18** was configured using a material having a thickness of 5 μm and a refractive index of 1.8.

[0101] In FIG. **7**, the anode **11** was configured using a material having a thickness of 200 nm and a refractive index of 0.3, the hole injection layer **12** was configured using a low refractive index material in a thickness of 10 nm, the hole transport layer **13** was configured using a material having a thickness of 20 nm and a refractive index of 1.7, and the light emitting layer **14** was configured using a material having a thickness of 90 nm and a refractive index of 1.7. In addition, in FIG. **7**, the electron transport layer **15** was configured using a material having a thickness of 30 nm and a refractive index of 1.8, the electron injection layer **16** was configured using a material having a thickness of 80 nm and a refractive index of 2.0, the cathode **17** was configured using a material having a thickness of 15 nm and a refractive index of 0.3, and the sealing layer **18** was configured using a material having a thickness of 5 μm and a refractive index of 1.8.

[0102] In FIG. **8**, the anode **11** was configured using a material having a thickness of 200 nm and a refractive index of 0.3, the hole injection layer **12** was configured using a low refractive index material in a thickness of 10 nm, the hole transport layer **13** was configured using a material having a thickness of 20 nm and a refractive index of 1.7, and the light emitting layer **14** was configured using a material having a thickness of 40 nm and a refractive index of 1.7. Besides, in FIG. **8**, the electron transport layer **15** was configured using a material having a thickness of 30 nm and a refractive index of 1.8, the electron injection layer **16** was configured using a material having a thickness of 80 nm and a refractive index of 2.0, the cathode **17** was configured using a material having a thickness of 15 nm and a refractive index of 0.3, and the sealing layer **18** was configured using a material having a thickness of 5 μm and a refractive index of 1.8.

[0103] As aforementioned, in the organic electroluminescence elements **1** that emit light in respective colors, the refractive index of the low refractive index layer is preferably higher than the refractive index (for example, 0.3) of the anode **11** and lower than the refractive index (for example, 1.7) of the light emitting layer **14**. In the organic electroluminescence element **1** that emits red light, the refractive index of the low refractive index layer is preferably not less than 0.75, at which the proportion of the waveguide mode increases. In the organic electroluminescence element **1** that emits red light, the refractive index of the low refractive index layer is preferably not more than 1.4, at which the external release mode becomes predominant over the evanescent mode. Therefore, in the organic electroluminescence element **1** that emits red light, the refractive index of the low refractive index layer is preferably a value in the range "a" in FIG. **7**, more preferably a value in the range "b" in FIG. **7**.

[0104] In the organic electroluminescence element **1** that emits green light, the refractive index of the low refractive index layer is preferably not less than 0.5, at which the proportion of the waveguide mode increases. Therefore, in the organic electroluminescence element **1** that emits green light, the refractive index of the low refractive index layer is preferably a value in the range "a" in FIG. **8**, more preferably a value in the range "c" in FIG. **8**.

[0105] In the organic electroluminescence element **1** that emits blue light, the refractive index of the low refractive index layer is preferably not less than 0.5, at which the proportion of the waveguide mode increases. In the organic electroluminescence element **1** that emits blue light, the refractive index of the low refractive index layer is preferably not more than 1.5, at which the proportion of the evanescent mode becomes not more than 50%. Therefore, in the organic electroluminescence element **1** that emits blue light, the refractive index of the low refractive index layer is preferably a value in the range "a" in FIG. **9**, more preferably a value in the range "d" in FIG. **9**.

[Effect]

[0106] Effects of the organic electroluminescence element **1** according to the present modification will be described below.

[0107] In the present modification, the low refractive index layer having a refractive index higher than the refractive index of the anode **11** and lower than the refractive index of the light emitting layer **14** is provided between the anode **11** and the light emitting layer **14**. This ensures that, to the light going from the light emitting layer **14** toward the low refractive index layer, the critical angle at the interface of the low refractive index layer is reduced, and, therefore, the proportion in which the light going from the light emitting layer **14** toward the low refractive index layer is reflected at the interface of the low refractive index layer is enhanced, as compared to the case where the low refractive index layer is not provided. As a result, the proportion of evanescent deactivation of excitons due, for example, to surface plasmon in the vicinity of the anode **11** is lowered, and, therefore, the proportions of the external release mode and the waveguide mode are increased. Accordingly, the injection or transport of holes into the light emitting layer **14** can be promoted and light extraction efficiency can be enhanced, by the low refractive index layer.

[0108] In addition, in the present modification, in the case where the low refractive index layer is configured using a material having a refractive index higher than 0.3 and lower than 1.7, the critical angle at the interface of the low refractive index layer is reduced, to the light going from the light emitting layer **14** toward the low refractive index layer, and, therefore, the proportion in which the light going from the light emitting layer **14** toward the low refractive index layer is reflected at the interface of the low refractive index layer is enhanced, as compared to the case where the low refractive index layer is not provided. As a result, the proportion of evanescent deactivation of excitons due, for example, to surface plasmon in the vicinity of the anode **11** is lowered, and, therefore, the proportions of external release mode and the waveguide mode are increased. Accordingly, the injection or transport of holes into the light emitting layer **14** can be promoted and light extraction efficiency can be enhanced, by the low refractive index layer.

[0109] Besides, in the organic electroluminescence element **1** that emits red light according to the present modification, in the case where the refractive index of the low refractive index layer is 0.75 to 1.4, the proportion of the waveguide mode is high, and the external release mode becomes predominant over the evanescent mode. This ensures that the injection or transport of holes into the light emitting layer **14** can be promoted and light extraction efficiency can be enhanced.

[0110] In addition, in the organic electroluminescence element **1** that emits green light according to the present modification, in the case where the refractive index of the low refractive index layer is 0.5 to 1.7, the proportion of the waveguide mode is high. This ensures that the injection or transport of holes into the light emitting layer **14** can be promoted and light extraction efficiency can be enhanced.

[0111] Besides, in the organic electroluminescence element **1** that emits blue light according to the present modification, in the case where the refractive index of the low refractive index layer is 0.5 to 1.5, the proportion of the waveguide mode is high, and the proportion of the evanescent mode is not more than 50%. This ensures that the injection or transport of holes into the light emitting layer **14** can be promoted and light extraction efficiency can be enhanced.

[Modification B]

[0112] FIG. **10** depicts a modification of the sectional configuration of the organic electroluminescence element **1** according to the above embodiment and Modification A. In the organic electroluminescence element **1** according to the present modification, a hole injection layer **12** includes, for example, a metallic oxide layer **12**A, and an organic matter layer **12**B stacked on the metallic oxide layer **12**A.

[0113] The metallic oxide layer **12**A includes tungsten oxide (compositional formula: WOx, in which x is a real number in the range of generally $2<x<3$). The film thickness of the metallic oxide layer **12**A is not less than 2 nm, and is, for example, 10 nm. The metallic oxide layer **12**A may contain such trace amounts of impurities as ordinarily allowed to mix in.

[0114] With the film thickness of the metallic oxide layer **12**A set to be not less than 2 nm, it is easy to form a uniform tungsten oxide film, and it is easy to form Schottky ohmic connection between the anode **11** and the metallic oxide layer **12**A described below. The Schottky ohmic connection is stably formed where the film thickness of the tungsten oxide film is not less than 2 nm. Therefore, when the tungsten oxide film is formed in a thickness larger than this value, a stable hole injection efficiency from the anode **11** into the metallic oxide layer **12**A can be expected to be achieved utilizing the Schottky ohmic connection. Note that the "Schottky ohmic connection" means a connection in which the difference between the Fermi level of the anode **11** and the lowest binding energy of the occupied level in the vicinity of the Fermi surface of the metallic oxide layer **12**A is not more than a predetermined value. The thickness of the metallic oxide layer **12**A is, for example, 5 to 20 nm.

[0115] The organic matter layer **12**B is formed in contact with the metallic oxide layer **12**A. The organic matter layer **12**B has an electron blocking property. The organic matter layer **12**B is formed using an organic material such as a conductive polymer material. The organic matter layer **12**B is formed, for example, by applying an organic polymer solution of a conductive polymer material such as PEDOT (a mixture of polythiophene and polystyrenesulfonic acid) to the metallic oxide layer **12**A, followed by drying. In this case, the organic matter layer **12**B includes a coating film. Further, for example, for solubility and an insolubilizing function, the organic matter layer **12**B has a soluble group and an insolubilized group such as a thermal dissociation soluble group, a crosslinking group or a dissociable protective group, in its molecular structure. In other words, the organic matter layer **12**B is an insolubilized layer.

[0116] The thickness of the organic matter layer **12**B of the blue organic electroluminescence element **1** is preferably not less than 20 nm, for example, from the viewpoint of light emission efficiency. Note that from the viewpoint of chromaticity, the thickness of the organic matter layer **12**B of the blue organic electroluminescence element **1** is preferably not less than 30 nm, for example. The thickness of the organic matter layer **12**B of the green organic electroluminescence element **1** is preferably 10 to 20 nm, for example, from the viewpoint of light emission efficiency. The thickness of the organic matter layer **12**B of the red organic electroluminescence element **12*r*** is preferably not less than 30 nm, for example, from the viewpoint of light emission efficiency. From the viewpoint of shortening the film forming time, the thickness of the organic matter layer **12**B of the red organic electroluminescence element **12*r*** is preferably not more than 50 nm, for example.

[Modification C]

[0117] FIG. **11** depicts a modification of the sectional configuration of the organic electroluminescence element **1** according to the above embodiment and Modification A. FIG. **12** depicts a modification of the sectional configuration of the organic electroluminescence element **1** according to Modification B. An organic electroluminescence element **1** according to the present modification has a light distribution control layer **19**, which makes contact with an upper surface of a cathode **17**, between the cathode **17** and a sealing layer

18. As depicted in FIG. **13**, the light distribution control layer **19** is a composite layer which includes, for example, light transmitting layers **19**A, **19**B and **19**C stacked in this order from the cathode **17** side. The light transmitting layers **19**A, **19**B and **19**C are formed, for example, using a transparent conductive material or a transparent dielectric material.

[0118] Examples of the transparent conductive material used for the light transmitting layers **19**A, **19**B and **19**C include ITO and IZO. Examples of the transparent dielectric material used for the light transmitting layers **19**A, **19**B and **19**C include silicon oxide (e.g., SiO_2), silicon oxynitride (e.g., SiON) and silicon nitride (e.g., SiN). The light transmitting layers **19**A, **19**B and **19**C may have a function as a cathode **17**, or may have a function as a passivation film. The light transmitting layers **19**A, **19**B and **19**C may be formed using a low refractive index material such as, for example, MgF or NaF.

[0119] An anode **11** and the light transmitting layers **19**A, **19**B and **19**C constitute a resonator structure. In the present modification, a sealing layer **18** also has a function of preventing external interference with the resonator structure configured between the anode **11** and the light transmitting layers **19**A, **19**B and **19**C.

[0120] On an upper surface of the anode **11**, a reflective surface S**1** is formed by a refractive index difference between the anode **11** and a layer (a hole injection layer **12** or a hole transport layer **13**) making contact with the upper surface of the anode **11**. The reflective surface S**1** is disposed at a position of an optical distance L**1** from a light emission center **14***a* of a light emitting layer **14**. The optical distance L**1** is set in such a manner that the light of a center wavelength **2**J of a light emission spectrum of the light emitting layer **14** is intensified by interference between the reflective surface S**1** and the light emission center **14***a*. Specifically, the optical distance L**1** is configured such as to satisfy the following expressions (1) and (2). Note that in the expressions (1) and (2), the unit of L**1**, **λ1** and **λ11** is nm.

$$(2L1/\lambda 11)+(a1/2\pi)=m1 \tag{1}$$

$$\lambda 1-150<\lambda 11<\lambda 1+80 \tag{2}$$

[0121] where

[0122] a**1** is the phase change when the light emitted from the light emitting layer **14** is reflected on the reflective surface S**1**;

[0123] **λ11** is a wavelength satisfying the expression (2); and

[0124] m**1** is an integer of not less than 0.

[0125] In the above, al can be calculated using n**0** and k of the complex refractive index N=n0−jk (n**0**: refractive index, k: extinction coefficient) of the anode **11** and the refractive index of the light emitting layer **14** (see, for example, Principles of Optics, Max Born and Emil Wolf, 1974 (PERGAMON PRESS) or the like). The complex refractive index of the anode **11** and the refractive index of the light emitting layer **14** can be measured using, for example, a spectroscopic ellipsometer.

[0126] If the value of m**1** is high, a so-called microcavity (microscopic resonator) effect cannot be obtained, and, therefore, it is preferable that m**1**=0. For instance, the optical distance L**11** preferably satisfies both of the following expressions (3) and (4). Note that in the expression (4), **λ1**=600 nm.

$$(2L1/\lambda 11)+(a1/2\pi)=0 \tag{3}$$

$$\lambda 1-150=450<\lambda 11=600<\lambda 1+80=680 \tag{4}$$

[0127] Since the reflective surface S**1** satisfying the expression (3) is provided at a position of zero-order interference, it indicates a high transmittance over a wide wavelength band. Therefore, as indicated in the expression (4), **λ11** can be largely deviated from the center wavelength **λ1**.

[0128] On an upper surface of the cathode **17**, a reflective surface S**2** is formed by the refractive index difference between the cathode **17** and a layer (light transmitting layer **19**A) making contact the upper surface of the cathode **17**. The reflective surface S**2** is disposed at a position of an optical distance L**2** from the light emission center **14***a* of the light emitting layer **14**. The optical distance L**2** is set in such a manner that the light of the center wavelength **2**J of the light emission spectrum of the light emitting layer **14** is intensified by interference between the reflective surface S**2** and the light emission center **14***a*. Specifically, the optical distance L**2** is configured such as to satisfy the following expressions (5) and (6). Note that in the expressions (5) and (6), the unit of L**2**, **λ1** and **λ12** are nm.

$$(2L2/\lambda 12)+(a2/2\pi)=m2 \tag{5}$$

$$\lambda 1-80<\lambda 12<\lambda 1+80 \tag{6}$$

[0129] where

[0130] a**2** is the phase change when the light emitted from the light emitting layer **14** is reflected on the reflective surface S**2**;

[0131] **λ12** is a wavelength satisfying the expression (6); and

[0132] m**2** is an integer of not less than 0.

[0133] In the above, a**2** can be calculated using n**0** and k of the complex refractive index N=n**0**−jk (n**0**: refractive index, k: extinction coefficient) of the light transmitting layer **19**A and the refractive index of the light emitting layer **14**. The complex refractive index of the light transmitting layer **19**A and the refractive index of the light emitting layer **14** can be measured using, for example, a spectroscopic ellipsometer.

[0134] If the value of m**2** is high, the so-called microcavity (microscopic resonator) effect cannot be obtained, and, therefore, it is preferable that m**2**=1.

[0135] Each of the reflective surfaces S**1** and S**2** is configured such that the light generated in the light emitting layer **14** is intensified between itself and the light emission center **14***a*. Due to this amplifying effect, a peak of transmittance is generated in the vicinity of 620 nm.

[0136] Note that, for example, as depicted in FIG. **14**, the cathode **17** may not be provided, the light transmitting layer **19**A may be provided with the role of the cathode **17**, and the reflective surface S**2** may be formed by the refractive index difference between the electron transport layer **15** or the electron injection layer **16** and the light transmitting layer **19**A.

[0137] In addition, for example as depicted in FIG. **15**, a light transmitting layer **19**D may be provided between the light transmitting layer **19**A and the light transmitting layer **19**B, and a reflective surface S**2** may be formed by the refractive index difference between the light transmitting layer **19**D and the light transmitting layer **19**A.

[0138] On an upper surface of the light transmitting layer **19**A, a reflective surface S**3** is formed by the refractive index difference between the light transmitting layer **19**A and a layer (light transmitting layer **19**B) making contact with the upper surface of the light transmitting layer **19**A. The reflective surface S**3** is disposed at a position of an optical distance L**3** from the light emission center **14***a* of the light emitting layer **14**. In the organic electroluminescence element **1** that emits red light, the optical distance L**3** is set in such a manner that the light of the center wavelength λ**1** (λ**1**R) of the light emission spectrum of the light emitting layer **14** is weakened by interference between the reflective surface S**3** and the light emission center **14***a*. In the organic electroluminescence element **1** that emits blue light, the optical distance L**3** is set in such a manner that the light of the center wavelength λ**1** (λ**1**B) of the light emission spectrum of the light emitting layer **14** is intensified by interference between the reflective surface S**3** and the light emission center **14***a*. Specifically, in the organic electroluminescence element **1** that emits red light, the optical distance L**3** is configured such as to satisfy the following expressions (7) and (8). In the organic electroluminescence element **1** that emits blue light, the optical distance L**3** is configured such as to satisfy the following expressions (9) and (10). Note that in the expressions (7), (8), (9) and (10), the unit of L**3**, λ**1**, λ**13** and λ**23** is nm.

$$(2L3/\lambda 13)+(a3/2\pi)=m3+1/2 \tag{7}$$

$$\lambda 1R-150<\lambda 13<\lambda 1R+150 \tag{8}$$

$$(2L3/\lambda 23)+(a3/2\pi)=n3 \tag{9}$$

$$\lambda 1B=150<\lambda 23<\lambda 1B+150 \tag{10}$$

[0139] where

[0140] a**3** is the phase change when the light emitted from the light emitting layer **14** is reflected on the reflective surface S**3**;

[0141] λ**13** is a wavelength satisfying the expression (8);

[0142] λ**23** is a wavelength satisfying the expression (10); and

[0143] m**3** and n**3** are each an integer of not less than 0.

[0144] On an upper surface of the light transmitting layer **19**B, a reflective surface S**4** is formed by the refractive index difference between the light transmitting layer **19**B and a layer (light transmitting layer **19**C) making contact with the upper surface of the light transmitting layer **19**B. The reflective surface S**4** is disposed at a position of an optical distance L**4** from the light emission center **14***a* of the light emitting layer **14**. In the organic electroluminescence element **1** that emits red light, the optical distance L**4** is set in such a manner that the light of the center wavelength **2**J (**2**JR) of the light emission spectrum of the light emitting layer **14** is weakened by interference between the reflective surface S**4** and the light emission center **14***a*. In the organic electroluminescence element **1** that emits blue light, the optical distance L**4** is set in such a manner that the light of the center wavelength λ**1** (λ**1**B) of the light emission spectrum of the light emitting layer **14** is intensified by interference between the reflective surface S**4** and the light emission center **14***a*. Specifically, in the organic electroluminescence element **1** that emits red light, the optical distance L**4** is configured such as to satisfy the following expressions (11) and (12). In the organic electroluminescence element **1** that emits blue light, the optical distance L**4** is configured such as to satisfy the following expressions (13) and (14). Note that in the expressions (11), (12), (13) and (14), the unit of L**4**, λ**1**, λ**14** and λ**24** is nm.

$$(2L4/\lambda 14)+(a4/2\pi)=m4+1/2 \tag{11}$$

$$\lambda 1R-150<\lambda 14<+150 \tag{12}$$

$$(2L4/\lambda 24)+(a3/2\pi)=n4 \tag{13}$$

$$\lambda 1B-150<\lambda 24<\lambda 1B+150 \tag{14}$$

[0145] where

[0146] a**4** is the phase change when the light emitted from the light emitting layer **14** is reflected on the reflective surface S**4**;

[0147] λ**14** is a wavelength satisfying the expression (11);

[0148] λ**24** is a wavelength satisfying the expression (13); and

[0149] m**4** and n**4** are each an integer of not less than 0.

[0150] In the above, a**3** can be calculated using n**0** and k of the complex refractive index N=n**0**−jk (n**0**: refractive index, k: extinction coefficient) of the light transmitting layer **19**B and the refractive index of the light emitting layer **14**. Similarly, a**4** can be calculated using n**0** and k of the complex refractive index N=n**0**−jk (n**0**: refractive index, k: extinction coefficient) of the light transmitting layer **19**C and the refractive index of the light emitting layer **14**. The complex refractive indexes of the light transmitting layers **19**B and **19**C and the refractive index of the light emitting layer **14** can be measured using, for example, a spectroscopic ellipsometer.

[0151] Though details will be described later, since the reflection conditions on the reflective surfaces S**3** and S**4** can thus be made different for the organic electroluminescence element **1** that emits red light and the organic electroluminescence element **1** that emits blue light, light emission state can be adjusted on the basis of the light emission color of the organic electroluminescence element **1**.

[0152] With the reflection on the reflective surface S**3** added, the light generated in the red light emitting layer **14** is weakened, and the half-value width of spectrum is broadened. In addition, with the reflection on the reflective surface S**4** added, the light generated in the red light emitting layer **14** is further weakened, and the half-value width of spectrum is further broadened. With the vicinity of a peak of the spectrum thus made gently sloped, sudden variations in luminance and hue with angle can be restrained. Besides, with the reflection on the reflective surface S**4** added, the light generated in the blue light emitting layer **14** is intensified, and a peak is enlarged. With a steep peak thus provided, light extraction efficiency can be enhanced. In addition, chromaticity point can also be enhanced. The positions of peaks of spectra formed by the reflective surfaces S**1** and S**2** and the positions of peaks of spectra formed by the reflective surfaces S**3** and S**4** may be matched to each other, or may be deviated from each other. In the case where the positions of peaks of spectra formed by the reflective surfaces S**1** and S**2** and the positions of peaks of spectra formed by the reflective surfaces S**3** and S**4** are deviated from each other, a wavelength band in which the effect of a resonator structure is obtained can be enlarged, and steep variations in luminance and hue can be restrained.

[0153] The organic electroluminescence element **1** that emits green light has, for example, the reflective surfaces S**1** to S**4** configured similarly to those of the organic electroluminescence element **1** that emits blue light. Specifically, the reflective surfaces S**1** to S**4** are configured in such a manner as to intensify the light with respect to the center wavelength of light emission spectrum of the green light emitting layer **14**.

[0154] Operation and effect of the organic electroluminescence element **1** according to the present modification will be described below. In the present modification, the light emitted from the light emitting layer **14** undergoes multiple reflections between the reflective surface S**1** and the reflective surface S**4**, before being extracted via a light extraction surface SDR. Meanwhile, in a general organic electroluminescence device, it is not easy to enhance light distribution characteristics.

[0155] For example, there has been proposed a method in which the film thickness between a light transmitting electrode and a reflective electrode is set such as to permit resonance of light of a desired wavelength, thereby enhancing light emission efficiency (see, for example, WO 01/039554). In addition, an attempt to control the balance of attenuation of the three primary colors (red, green and blue) by, for example, controlling the film thicknesses of organic layers, to thereby enhance viewing angle characteristics of chromaticity point of white color (see, for example, JP 2011-159433A).

[0156] In these configurations, however, a stacked structure of the organic electroluminescence element functions as an interference filter having a narrow half-value width, for the spectrum of the light extracted. Therefore, when a light extraction surface is viewed obliquely, the wavelength of light is largely shifted. Accordingly, a lowering in light emission intensity or the like is generated depending on the viewing angle, and viewing angle dependency is increased.

[0157] Besides, for example, JP 2006-244713A proposes a structure for reducing variations in hue with viewing angle. However, although it may be possible to apply this structure to monochrome and to reduce the viewing angle dependency of luminance, it is difficult to apply this structure to a sufficiently wide wavelength band. Although it may be contemplated to enhance reflectance in order to widen the wavelength band to which this structure is applicable, such an approach leads to a conspicuous lowering in light extraction efficiency.

[0158] While a method of reducing the viewing angle dependency by adjusting the positional relation in the stacked structure of the organic electroluminescence element, light emission position or the like may be contemplated, the adjustment in this method may be difficult to accomplish, for example, in the case where wavelength dispersion of refractive index is generated due to the spectra of lights emitted from the light emitting layers. In the wavelength dispersion of refractive index, the refractive indexes of constituent materials differ depending on the wavelength, and, therefore, differences in the effect of a resonator structure are generated between the red organic electroluminescence element, the green organic electroluminescence element and the blue organic electroluminescence element. For instance, in the red organic electroluminescence element, the peak of the red light extracted is too steep, whereas in the blue organic electroluminescence element, the peak of the blue light extracted is too gently sloped. If the effect of the resonator structure thus differs largely on the basis of element region, angle dependencies of luminance and hue are enlarged, and light distribution characteristic is lowered.

[0159] On the other hand, in the present modification, the influence of the reflective surfaces S**3** and S**4** on the light generated in the red light emitting layer **14** and the influence of the reflective surfaces S**3** and S**4** on the light generated in the blue light emitting layer **14** are different from each other. Specifically, the light generated in the red light emitting layer **14** and the light generated in the blue light emitting layer **14** become as follows.

[0160] The light generated in the red light emitting layer **14** is weakened by interference between the light emission center **14***a* of the red light emitting layer **14** and the reflective surfaces S**3** and S**4** of the red sub-pixel **22**R. On the other hand, the light generated in the blue light emitting layer **14** is intensified by interference between the light emission center **14***a* of the blue light emitting layer **14** and the reflective surfaces S**3** and S**4** of the blue organic electroluminescence element **1**.

[0161] As a result, in the red organic electroluminescence element **1**, red light in which the vicinity of a peak is gently sloped is extracted via the light extraction surface SDR, whereas in the blue organic electroluminescence element **1**, blue light having a steep peak is extracted via the light extraction surface SDB. Therefore, the difference between the effect of the resonator structure of the red organic electroluminescence element **1** and the effect of the resonator structure of the blue organic electroluminescence element **1** is reduced, so that viewing angle dependencies of luminance and hue are reduced. Accordingly, light distribution characteristics can be enhanced. In addition, the organic electroluminescence device **2** having high light distribution characteristics is preferably applicable also to a display device requiring high image quality, so that productivity of display device can be enhanced. In the organic electroluminescence element **1** according to the present modification, $\Delta uv \leq 0.015$ and a luminance of not less than 60% can be maintained even at a viewing angle of 45°, and high image quality can be realized.

[0162] As above-mentioned, in the organic electroluminescence element **1** according to the present modification, the reflective surfaces S**3** and S**4** of the red sub-pixel **22**R are provided such as to weaken the light generated in the red light emitting layer **14**, whereas the reflective surfaces S**3** and S**4** of the blue sub-pixel **22**B are provided such as to intensify the light generated in the blue light emitting layer **14**. As a result, the effect of the resonator structure can be adjusted on a sub-pixel **22** basis, and, therefore, light distribution characteristics can be enhanced.

[0163] In addition, since a high light transmittance can be obtained over a wide wavelength band, light extraction efficiency can be enhanced. As a result, power consumption can also be suppressed.

[0164] Note that in the case where the reflective surfaces S**3** and S**4** are formed by stacking metal thin films having a thickness of not less than 5 nm, a high light transmittance can be obtained over a wide wavelength band.

[0165] Besides, the organic electroluminescence element **1** according to the present modification is preferable for the case where the light emitting layers **14** are printed layers. The light emitting layers **14** are, by passing through a drying process, for example, susceptible to generation of variations in thickness depending on regions. In other words, the light emitting layers **14** are susceptible to generation of a film thickness distribution. In the organic electroluminescence element **1** according to the present modification, the difference in the effect of the resonator structure on the organic electroluminescence element **1** basis due to the film thickness distribution can be adjusted.

3. SECOND EMBODIMENT

[Configuration]

[0166] FIG. **16** depicts a general configuration example of an organic electroluminescence device **2** according to a second embodiment of the present disclosure. FIG. **17** depicts an example of circuit configuration of a sub-pixel **22** included in each pixel **21** provided in the organic electroluminescence device **2**. The organic electroluminescence device **2** includes, for example, an organic electroluminescence panel **20**, a controller **30** and a driver **40**. The driver **40** is mounted, for example, at an outer edge portion of the organic electroluminescence panel **20**. The organic electroluminescence panel **20** has a plurality of pixels **21** arranged in a matrix pattern. The controller **30** and the driver **40** drive the organic electroluminescence panel **20** (the plurality of pixels **21**), based on a video signal Din and a synchronizing signal Tin inputted externally.

(Organic Electroluminescence Panel **20**)

[0167] The organic electroluminescence panel **20** has the pixels **21** subjected to active matrix driving by the controller **30** and the driver **40**, thereby displaying an image based on the video signal Din and the synchronizing signal Tin which are externally inputted. The organic electroluminescence panel **20** includes a plurality of scanning lines WSL extending in a row direction, a plurality of signal lines DTL and a plurality of power source lines DSL extending in a column direction, and the plurality of pixels **21** arranged in a matrix pattern.

[0168] The scanning lines WSL are used for selection of each of the pixels **21**, and supply the pixels **21** with selection pulses for selecting the pixels **21** on the basis of a predetermined unit (for example, pixel row). The signal lines DTL are used for supplying the pixels **21** with signal voltages Vsig according to the video signal Din, and supply the pixels **21** with data pulses including the signal voltages Vsig. The power source lines DSL supply the pixels **21** with electric power.

[0169] Each of the pixels **21** includes, for example, a sub-pixel **22** that emits red light, a sub-pixel **22** that emits green light, and a sub-pixel **22** that emits blue light. Note that each pixel **21** may further include, for example, a sub-pixel **22** that emits light in other color (for example, white or yellow). In each pixel **21**, the plurality of sub-pixels **22** are disposed, for example, in a line in a predetermined direction.

[0170] Each of the signal lines DTL is connected to an output end of a horizontal selector **41** which will be described later. The plurality of signal lines DTL are assigned, for example, one to each pixel column. Each of the scanning lines WSL is connected to an output end of a light scanner **42** which will be described later. The plurality of scanning lines WSL are assigned, for example, one to each pixel row. Each of the power source lines DSL is connected to an output end of a power source. The plurality of power source lines DSL are assigned, for example, one to each pixel row.

[0171] Each of the sub-pixels **22** includes a pixel circuit **22-1** and an organic electroluminescence element **22-2**. The organic electroluminescence element **22-2** is the organic electroluminescence element **1** according to the above-described first embodiment, Modification A and Modification B.

[0172] The pixel circuit **22-1** controls light emission and quenching of the organic electroluminescence element **22-2**. The pixel circuit **22-1** has a function of holding a voltage written into each sub-pixel **22** by write scanning which will be described later. The pixel circuit **22-1** includes, for example, a driving transistor Tr**1**, a writing transistor Tr**2** and a storage capacitor Cs.

[0173] The writing transistor Tr**2** controls the application of the signal voltage Vsig corresponding to the video signal Din to a gate of the driving transistor Tr**1**.

[0174] Specifically, the writing transistor Tr**2** samples voltages on the signal lines DTL, and writes a voltage obtained by sampling into the gate of the driving transistor Tr**1**. The driving transistor Tr**1** is connected in series with the organic electroluminescence element **22-2**. The driving transistor Tr**1** drives the organic electroluminescence element **22-2**. The driving transistor Tr**1** controls a current flowing in the organic electroluminescence element **22-2** according to the magnitude of the voltage sampled by the writing transistor Tr**2**. The storage capacitor Cs is for holding a predetermined voltage between the gate and the source of the driving transistor Tr**1**. The storage capacitor Cs has a role of keeping constant a gate-source voltage Vgs of the driving transistor Tr**1** during a predetermined period. Note that the pixel circuit **22-1** may have a circuit configuration obtained by adding various capacitors and transistors to the above-mentioned 2Tr**1** C circuit, or may have a circuit configuration different from the 2Tr**1** C circuit configuration.

[0175] Each signal line DTL is connected to an output end of the horizontal selector **41** which will be described later and to the source or drain of the writing transistor Tr**2**. Each scanning line WSL is connected to an output end of the light scanner **42** which will be described later and to the gate of the writing transistor Tr**2**. Each power source line DSL is connected to a power source circuit and to the source or drain of the driving transistor Tr**1**.

[0176] The gate of the writing transistor Tr**2** is connected with the scanning line WSL. The source or drain of the writing transistor Tr**2** is connected with the signal line DTL. That terminal of the source and the drain of the writing transistor Tr**2** which is not connected with the signal line DTL is connected to the gate of the driving transistor Tr**1**. The source or the drain of driving transistor Tr**1** is connected with the power source line DSL. That terminal of the source and the drain of the driving transistor Tr**1** which is not connected with the power source line DSL is connected to the anode **11** of the organic electroluminescence element **21-2**. One end of the storage capacitor Cs is connected to the gate of the driving transistor Tr**1**. The other end of the storage capacitor Cs is connected to that terminal of the source and the drain of the driving transistor Tr**1** which is located on the organic electroluminescence element **21-2** side.

(Driver **40**)

[0177] The driver **40** includes, for example, the horizontal selector **41** and the light scanner **42**. The horizontal selector **41** applies the analog signal voltage Vsig, inputted from the controller **30**, to each signal line DTL according to (synchronously with) the inputting of a control signal, for example. The light scanner **42** scans the plurality of sub-pixels **22** on the basis of a predetermined unit.

(Controller **30**)

[0178] The controller **30** will be described below. The controller **30** applies predetermined correction to the digital video signal Din inputted externally, for example, and generates the signal voltage Vsig, based on the video signal obtained by the correction. The controller **30** outputs the generated signal voltage Vsig, for example, to the horizontal selector **41**. The controller **30** outputs a control signal to each circuit in the driver **40**, according to (synchronously with) the synchronizing signal Tin inputted externally, for example.

[0179] Referring to FIGS. **18**, **19**, **20** and **21**, the organic electroluminescence element **22-2** will be described below. FIG. **18** depicts a general configuration example of the organic electroluminescence panel **20**. FIG. **19** depicts a sectional configuration example, along line A-A, of the organic electroluminescence panel **20** of FIG. **14** (namely, a sectional configuration example in the row direction of the sub-pixel **22** (**22**R)). FIG. **20** depicts a sectional configuration example, along line B-B, of the organic electroluminescence panel **20** of FIG. **18** (namely, a sectional configuration example in the column direction of the sub-pixel **22** (**22**R)). FIG. **21** depicts a sectional configuration example, along line C-C, of the organic electroluminescence panel **20** of FIG. **18** (namely, a sectional configuration example in the column direction of the sub-pixel **22** (**22**R)). Note that in FIG. **20** is illustrated a sectional configuration example at a part avoiding a crosspiece section **24**B which will be described later. In FIG. **21** is illustrated a sectional configuration example at a part including the crosspiece section **24**B.

[0180] The organic electroluminescence panel **20** has the plurality of pixels **21** arranged in a matrix pattern. Each of the pixels **21** includes, for example, as aforementioned, the sub-pixel **22** (**22**R) that emits red light, the sub-pixel **22** (**22**G) that emits green light, and the sub-pixel **22** (**22**B) that emits blue light.

[0181] The sub-pixel **22**R includes an organic electroluminescence element **22-2** (**22***r*) that emits red light. The sub-pixel **22**G includes an organic electroluminescence element **22-2** (**22***g*) that emits green light. The sub-pixel **22**B includes an organic electroluminescence element **22-2** (**22***b*) that emits blue light. The sub-pixels **22**R, **22**G and **22**B are arranged, for example, in a pattern of stripes. In each pixel **21**, the sub-pixels **22**R, **22**G and **22**B are aligned in the row direction, for example. Further, in each pixel row, the plurality of sub-pixels **22** that emits light in the same color are aligned in the column direction, for example.

[0182] The organic electroluminescence panel **20** has a substrate **10**. The substrate **10** includes, for example, a base material that supports the organic electroluminescence elements **22-2**, the insulating layer **24** and the line banks **23**, and a wiring layer provided over the base material. The base material in the substrate **10** is formed using, for example, non-alkali glass, soda glass, nonfluorescent glass, phosphate glass, borate glass, quartz or the like. The base material in the substrate **10** may be formed using, for example, acrylic resin, styrene resin, polycarbonate resin, epoxy resin, polyethylene, polyester, silicone resin, or alumina or the like. The wiring layer in the substrate **10** is formed, for example, with the pixel circuits **22-1** of the pixels **21**.

[0183] The organic electroluminescence panel **20** further includes the insulating layer **24** over the substrate **10**. The insulating layer **24** is for partitioning the sub-pixels **22**. An upper limit for the thickness of the insulating layer **24** is preferably in such a range that shape control can be made on a manufacturing basis, from the viewpoint of control of variability in film thickness and bottom line width, and is preferably not more than 10 μm. In addition, the upper limit for the thickness of the insulating layer **24** is preferably in such a range that an increase in tact due to an increase in exposure time in an exposure process can be restrained and that a lowering in productivity in a mass production process can be restrained, and is more preferably not more than 7 μm. Besides, a lower limit for the thickness of the insulating layer **24** is determined by a resolution limit concerning an exposure apparatus and materials, since the bottom line width should be supplemented to substantially the same with the film thickness as the film thickness decreases. The lower limit for the thickness of the insulating layer **24** is preferably not less than 1 μm, in the case of using a semiconductor stepper, and is preferably not less than 2 μm, in the case of using a stepper and a scanner for flat panels. Therefore, the thickness of the insulating layer **24** is preferably 1 to 10 μm, and more preferably 2 to 7 μm.

[0184] The insulating layer **24** includes a plurality of column restricting sections **24**C and a plurality of row restricting sections **24**D that partition the sub-pixels **22**. Each column restricting section **24**C extends in the column direction, and each row restricting section **24**D extends in the row direction. The plurality of column restricting sections **24**C extend in the column direction, and are aligned in parallel at a predetermined spacing in the row direction. The plurality of row restricting sections **24**D extend in the row direction, and are aligned in parallel at a predetermined spacing in the column direction. The plurality of column restricting sections **24**C and the plurality of row restricting sections **24**D are intersecting (for example, orthogonally intersecting) each other, in a grid layout as a whole. Each sub-pixel **22** is surrounded by two adjacent column restricting sections **24**C and two adjacent row restricting sections **24**D, whereby each sub-pixel **22** is partitioned.

[0185] The insulating layer **24** includes, for each sub-pixel **22**, a plurality of (for example, two) crosspiece sections **24**B extending in the column direction. The plurality of crosspiece sections **24**B extend in the column direction and are aligned in parallel at a predetermined spacing in the row direction. Further, the insulating layer **24** includes a plurality of (for example, three) slit-shaped openings **24**A at that part in the region surrounded by two adjacent column restricting sections **24**C and two adjacent row restricting sections **24**D at which the crosspiece section **24**B is not formed. At a bottom surface of each opening **24**A, a surface of the anode **11** which will be described later is exposed. Therefore, holes supplied from the anode **11** exposed at the bottom surface of each opening **24**A and electrons supplied from a cathode **17** which will be described later re-combine each other in the light emitting layer **14** which will be described later, whereby light emission is generated in the light emitting layer **14** which will be described. Therefore, of the light emitting layer **14** described later, a region facing the opening **24**A is a light emitting region **14**A.

[0186] For example, as depicted in FIGS. **18** to **21**, each of the crosspiece sections **24**B may be formed such as to range over the two adjacent row restricting sections **24**D, or, for example, as depicted in FIGS. **22** to **24**, each crosspiece section **24**B may be formed at a part spaced from the two adjacent row restricting sections **24**D. FIG. **22** depicts a general configuration example of the organic electroluminescence panel **20**. FIG. **23** depicts a sectional configuration example, along line B-B, of the organic electroluminescence panel **20** of FIG. **22** (namely, a sectional configuration example in the column direction of the sub-pixel **22** (**22**R)). FIG. **24** depicts a sectional configuration example, along line C-C, of the organic electroluminescence panel **20** of

[0187] FIG. **22** (namely, a sectional configuration example in the column direction of the sub-pixel **22** (**22**R)). Note that a sectional configuration example, along line A-A, of the organic electroluminescence panel **20** of FIG. **22** (namely, a sectional configuration example in the row direction of the sub-pixel **22** (**22**R)) is in common with FIG. **19** above.

[0188] The height of the row restricting sections **24**D is smaller than the height of the column restricting sections **24**C as depicted in FIGS. **18** to **21**, for example. In this instance, the plurality of sub-pixels **22** aligned in the column direction ae disposed in belt-shaped groove sections formed by the left and right two column restricting sections **24**C of these sub-pixels **22**, and share, for example, the light emitting layer **14**, the electron transport layer **15** and the electron injection layer **16**. Note that the plurality of sub-pixels **22** aligned in the column direction may share, for example, the hole injection layer **12**, the hole transport layer **13**, the light emitting layer **14**, the electron transport layer **15** and the electron injection layer **16**. Note that the height of the row restricting sections **24**D may be the same as the height of the column restricting sections **24**C, as depicted in FIGS. **22** to **24** and FIG. **19**, for example. In this instance, the sub-pixels **22** are each disposed in a hollow formed by the two adjacent column restricting sections **24**C and the two adjacent row restricting sections **24**D, and, for example, have individually separate light emitting layers **14**.

[0189] The section in the row direction of each opening **24**A is a trapezoid upwardly enlarged in width as depicted in FIG. **19**, for example. In addition, the section in the column direction of each opening **24**A is a trapezoid upwardly enlarged in width as depicted in FIGS. **20** and **23**, for example. Specifically, side surfaces of each opening **24**A is of a reflector structure for building up the light generated from the light emitting layer **14** which will be described later. Let the refractive index of the sealing layer **18** be n_1 and let the refractive index of the insulating layer **24** be n_2, then n_1 and n_2 satisfy the following expressions (15) and (16). Here, n_2 is preferably 1.4 to 1.6. As a result, efficiency of extraction to the exterior of the light generated from the light emitting layer **14** which will be described later is enhanced.

$$1.1 \leq n_1 \leq 1.8 \tag{15}$$

$$|n_1 - n_2| \geq 0.20 \tag{16}$$

[0190] In addition, further, the depth D of the openings **24**A (namely, the thickness of the insulating layer **24**), the opening width Wh on the upper surface side of the insulating layer **24**, and the opening width WL on the upper surface side of the insulating layer **24** preferably satisfy the following expressions (17) and (18).

$$0.5 \leq WL/Wh \leq 0.8 \tag{17}$$

$$0.5 \leq D/WL \leq 2.0 \tag{18}$$

[0191] With such shapes and refractive index conditions, the efficiency of extraction of light from the light emitting layer **14** can be enhanced by the reflector structure owing to the opening **24**A of the insulating layer **24**. As a result, according to the present inventors' investigations, the luminance per sub-pixel **22** can be increased to 1.2 to 1.5 times that in the case where the reflector structure is not provided.

[0192] The insulating layer **24** is formed using, for example, an insulating organic material. Examples of the insulating organic material include acrylic resins, polyimide resins, and novolak type phenolic resins. The insulating layer **24** is preferably formed using, for example, an insulating resin having heat resistance and solvent resistance. The column restricting sections **24**C and the row restricting sections **24**D are formed, for example, by processing the insulating resin into a desired pattern by photolithography and development. The sectional shape of the column restricting section **24**C is, for example, of a normally tapered form, as depicted in FIG. **19**. The sectional shape of the row restricting section **24**D is, for example, of a normally tapered form, as depicted in FIG. **20**.

[0193] In the present embodiment, the organic electroluminescence element **1** according to the first embodiment, Modification A and Modification B is used as the organic electroluminescence element **22-2** of each sub-pixel **22**. As a result, it is possible to realize the organic electroluminescence panel **20** and the organic electroluminescence device **2** which are high in light extraction efficiency.

4. MODIFICATION OF SECOND EMBODIMENT

[0194] In the second embodiment, each organic electroluminescence element **22-2** may include a light distribution control layer **19** over the cathode **17**, as depicted in FIGS. **25**, **26** and **27**, for example. Note that FIG. **25** depicts a sectional configuration example, along line A-A, of the organic electroluminescence panel **20** of FIG. **18** (namely, a sectional configuration example in the row direction of the sub-pixel **22** (**22**R)). FIG. **26** depicts a sectional configuration example, along line B-B, of the organic electroluminescence panel **20** of FIG. **18** (namely, a sectional configuration example in the column direction of the sub-pixel **22** (**22**R)). FIG. **27** depicts a sectional configuration example, along line C-C, of the organic electroluminescence panel **20** of FIG. **18** (namely, a sectional configuration example in the column direction of the sub-pixel **22** (**22**R)).

[0195] In the present modification, the light distribution control layer **19** is provided, for example, between the cathode **17** and the sealing layer **18**. The light distribution control layer **19** may be formed, for example, in contact with the whole part of the surface of the cathode **17**.

[0196] In the present modification, the influence of the reflective surfaces S**3** and S**4** on the light generated in the red light emitting layer **14** and the influence of the reflective surfaces S**3** and S**4** on the light generated in the blue light emitting layer **14** are different from each other. Specifically, the light generated in the red light emitting layer **14** and the light generated in the blue light emitting layer **14** become as follows.

[0197] The light generated in the red light emitting layer **14** is weakened by interference between the light emission center **14***a* of the red light emitting layer **14** and the reflective surfaces S3 and S4 of the red sub-pixel **22**R. On the other hand, the light generated in the blue light emitting layer **14** is intensified by interference between the light emission center **14***a* of the blue light emitting layer **14** and the reflective surfaces S**3** and S**4** of the blue organic electroluminescence element **1**.

[0198] As a result, in the red organic electroluminescence element **1**, red light with the vicinity of a peak gently sloped is extracted via the light extraction surface SDR, whereas in the blue organic electroluminescence element **1**, blue light with a steep peak is extracted through the light extraction surface SDB. Therefore, the difference between the effect of the resonator structure of the red organic electroluminescence element **1** and the effect of the resonator structure of the blue organic electroluminescence element **1** is reduced, so that angle dependencies of luminance and hue are reduced. Accordingly, light distribution characteristics can be enhanced. In addition, the organic electroluminescence device **2** having high light distribution characteristics is preferable also for a display device requiring high image quality, and productivity of the display device can be enhanced.

5. APPLICATION EXAMPLES

Application Example 1

[0199] Hereinafter, an application example of the organic electroluminescence device **2** according to the above-described second embodiment and modifications will be described. The organic electroluminescence device **2** according to the above second embodiment and modifications is applicable to display devices of electronic apparatuses in any field in which a video signal inputted externally or a video signal generated internally is displayed as an image or a video image, such as television sets, digital cameras, notebook type personal computers, sheet-shaped personal computers, portable terminal devices such as mobile phones, and video cameras.

[0200] FIG. **28** depicts the external appearance of an electronic apparatus **3** according to the present application example, as viewed obliquely. The electronic apparatus **3** is, for example, a sheet-shaped personal computer including a display surface **320** at a main surface of a housing **310**. The electronic apparatus **3** has the organic electroluminescence device **2** according to the above second embodiment and its modifications at the display surface **320** of the electronic apparatus **3**. The organic electroluminescence device **2** according to the second embodiment and its modifications is disposed with the organic electroluminescence panel **20** directed to the outside. In the present application example, since the organic electroluminescence device **2** according to the above second embodiment and its modifications is provided at the display surface **320**, an electronic apparatus **3** high in light emission efficiency can be realized.

Application Example 2

[0201] Hereinafter, an application example of the organic electroluminescence element **22-2** according to the above-described second embodiment and its modifications will be described. The organic electroluminescence element **22-2** according to the above second embodiment and its modifications is applicable to light sources of illumination devices in any field, such as desk or floor type illumination devices or room illumination devices.

[0202] FIG. **29** depicts the external appearance of a room illumination device to which the organic electroluminescence element **22-2** according to the second embodiment and its modifications is applied. This illumination device has, for example, an illuminating section **410** including one or a plurality of organic electroluminescence elements **22-2** according to the second embodiment and its modifications. The illuminating sections **410** are disposed in an appropriate number and at appropriate intervals on a ceiling **420** of a building. Note that the illuminating sections **410** may be disposed, according to the use, in any places such as a wall **430** or a floor (not illustrated) as well as on the ceiling **420**.

[0203] In these illumination devices, illumination is performed by light from the organic electroluminescence element **22-2** according to the second embodiment and its modifications. As a result, an illumination device high in light emission efficiency can be realized.

[0204] While the present disclosure has been described above by embodiments thereof, the present disclosure is not limited to the embodiments, and various modifications are possible. Note that the effects described herein are mere examples, and the effects of the present disclosure are not limited to the effects described herein. The present disclosure may have other effects than those described herein.

[0205] In addition, the present disclosure may take, for example, the following configurations.

[0206] (1)

[0207] An organic electroluminescence element including:

[0208] an anode, a light emitting layer and a cathode in this order; and

[0209] a low refractive index layer lower in refractive index than the light emitting layer at at least one of a position between the light emitting layer and the cathode and a position between the anode and the light emitting layer.

[0210] (2)

[0211] The organic electroluminescence element as described in the above paragraph (1),

[0212] in which the low refractive index layer is disposed between the light emitting layer and the cathode, and is configured using a material which has an electron transporting property or an electron injecting property.

[0213] (3)

[0214] The organic electroluminescence element as described in the above paragraph (1),

[0215] in which the low refractive index layer is disposed between the anode and the light emitting layer, and is configured using a material which has a hole injecting property or a hole transporting property.

[0216] (4)

[0217] The organic electroluminescence element as described in the above paragraph (2) or (3),

[0218] in which the low refractive index layer is configured using a material having a refractive index of more than 0.3 and less than 1.7.

[0219] (5)

[0220] The organic electroluminescence element as described in the above paragraph (3),

[0221] in which the low refractive index layer is configured using a material having a refractive index of 0.75 to 1.4.

[0222] (6)

[0223] The organic electroluminescence element as described in the above paragraph (2) or (3),

[0224] in which the low refractive index layer is configured using a material having a refractive index of 0.5 to 1.7.

[0225] (7)

[0226] The organic electroluminescence element as described in the above paragraph (3),

[0227] in which the low refractive index layer is configured using a material having a refractive index of 0.5 to 1.5.

[0228] (8)

[0229] An organic electroluminescence panel including:

[0230] a plurality of pixels,

[0231] in which each of the pixels has an organic electroluminescence element, and the organic electroluminescence element includes

[0232] an anode, a light emitting layer and a cathode in this order, and

[0233] a low refractive index layer lower in refractive index than the light emitting layer at at least one of a position between the light emitting layer and the cathode and a position between the anode and the light emitting layer.

[0234] (9)

[0235] The organic electroluminescence panel as described in the above paragraph (8),

[0236] in which the low refractive index layer is shared by the pixels.

[0237] (10)

[0238] An electronic apparatus including:

[0239] an organic electroluminescence panel; and

[0240] a driving circuit that drives the organic electroluminescence panel, in which the organic electroluminescence panel includes a plurality of pixels,

[0241] each of the pixels has an organic electroluminescence element, and

[0242] the organic electroluminescence element includes

[0243] an anode, a light emitting layer and a cathode in this order, and

[0244] a low refractive index layer lower in refractive index than the light emitting layer at at least one of a position between the light emitting layer and the cathode and a position between the anode and the light emitting layer.

What is claimed is:

1. An organic electroluminescence element comprising:

an anode, a light emitting layer and a cathode in this order; and

a low refractive index layer lower in refractive index than the light emitting layer at at least one of a position between the light emitting layer and the cathode and a position between the anode and the light emitting layer.

2. The organic electroluminescence element according to claim **1**,

wherein the low refractive index layer is disposed between the light emitting layer and the cathode, and is configured using a material which has an electron transporting property or an electron injecting property.

3. The organic electroluminescence element according to claim **2**,

wherein the low refractive index layer is configured using a material having a refractive index of more than 0.3 and less than 1.7.

4. The organic electroluminescence element according to claim **2**,

wherein the low refractive index layer is configured using a material having a refractive index of 0.5 to 1.7.

5. An organic electroluminescence panel comprising:

a plurality of pixels,

wherein each of the pixels has an organic electroluminescence element, and

the organic electroluminescence element includes

an anode, a light emitting layer and a cathode in this order, and

a low refractive index layer lower in refractive index than the light emitting layer at at least one of a position between the light emitting layer and the cathode and a position between the anode and the light emitting layer.

6. The organic electroluminescence panel according to claim **5**,

wherein the low refractive index layer is shared by the pixels.

7. An electronic apparatus comprising:

an organic electroluminescence panel; and

a driving circuit that drives the organic electroluminescence panel,

wherein the organic electroluminescence panel includes a plurality of pixels,

each of the pixels has an organic electroluminescence element, and

the organic electroluminescence element includes

an anode, a light emitting layer and a cathode in this order, and

a low refractive index layer lower in refractive index than the light emitting layer at at least one of a position between the light emitting layer and the cathode and a position between the anode and the light emitting layer.

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专利名称(译)	有机电致发光元件，有机电致发光面板和电子设备

公开(公告)号	US20200098831A1	公开(公告)日	2020-03-26
申请号	US16/554626	申请日	2019-08-29

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IPC分类号	H01L27/32 H01L51/52 H01L51/50
CPC分类号	G09G3/3233 H01L51/5072 H01L51/5218 H01L51/5221 H01L51/5092 H01L27/3206 G09G2300/0842 H01L27/3211 H01L27/3246 H01L51/5056 H01L51/5088 H01L51/5262 H01L51/5265 H01L51/5271 H01L51/5275
优先权	2018175874 2018-09-20 JP 2019091166 2019-05-14 JP
外部链接	Espacenet USPTO

摘要(译)

公开了一种有机电致发光元件，该有机电致发光元件依次包括：阳极，发光层和阴极；阳极；发光层和阴极。 在发光层与阴极之间的位置和阳极与发光层之间的位置中的至少一者处具有比发光层低的折射率的低折射率层。