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(54) ORGANIC EL DISPLAY DEVICE

(71) Applicant: **Sharp Kabushiki Kaisha**, Sakai City, Osaka (JP)

(72) Inventors: **Tomoaki JO**, Sakai City (JP); **Shinichi KAWATO**, Sakai City (JP); **Manabu NIBOSHI**, Sakai City (JP); **Yuto TSUKAMOTO**, Sakai City (JP); **Hiroshi IMADA**, Sakai City (JP); **Tokiyoshi UMEDA**, Sakai City (JP); **Bai ZHANG**, Sakai City (JP)

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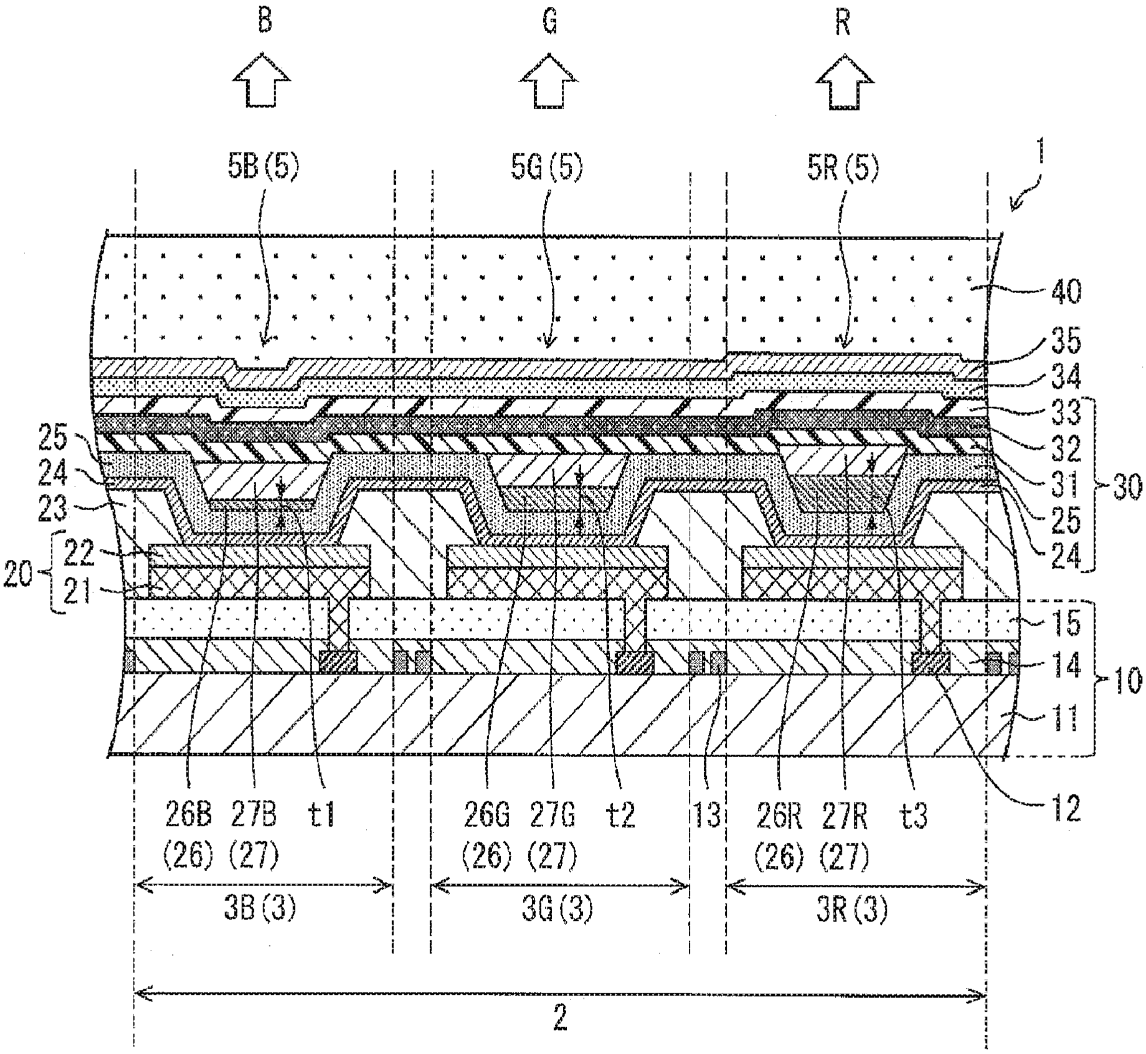
(57) **ABSTRACT**

An individual hole transport layer is individually disposed between a common hole transport layer and a light emitting layer in each sub pixel, and the energy level value of the lowest unoccupied molecular orbital of the individual hole transport layer is smaller than the energy level value of the lowest unoccupied molecular orbital of the common hole transport layer, but larger than the energy level value of the lowest unoccupied molecular orbital of the light emitting layer in sub pixel. Thus, a hole can be efficiently injected into the light emitting layer.



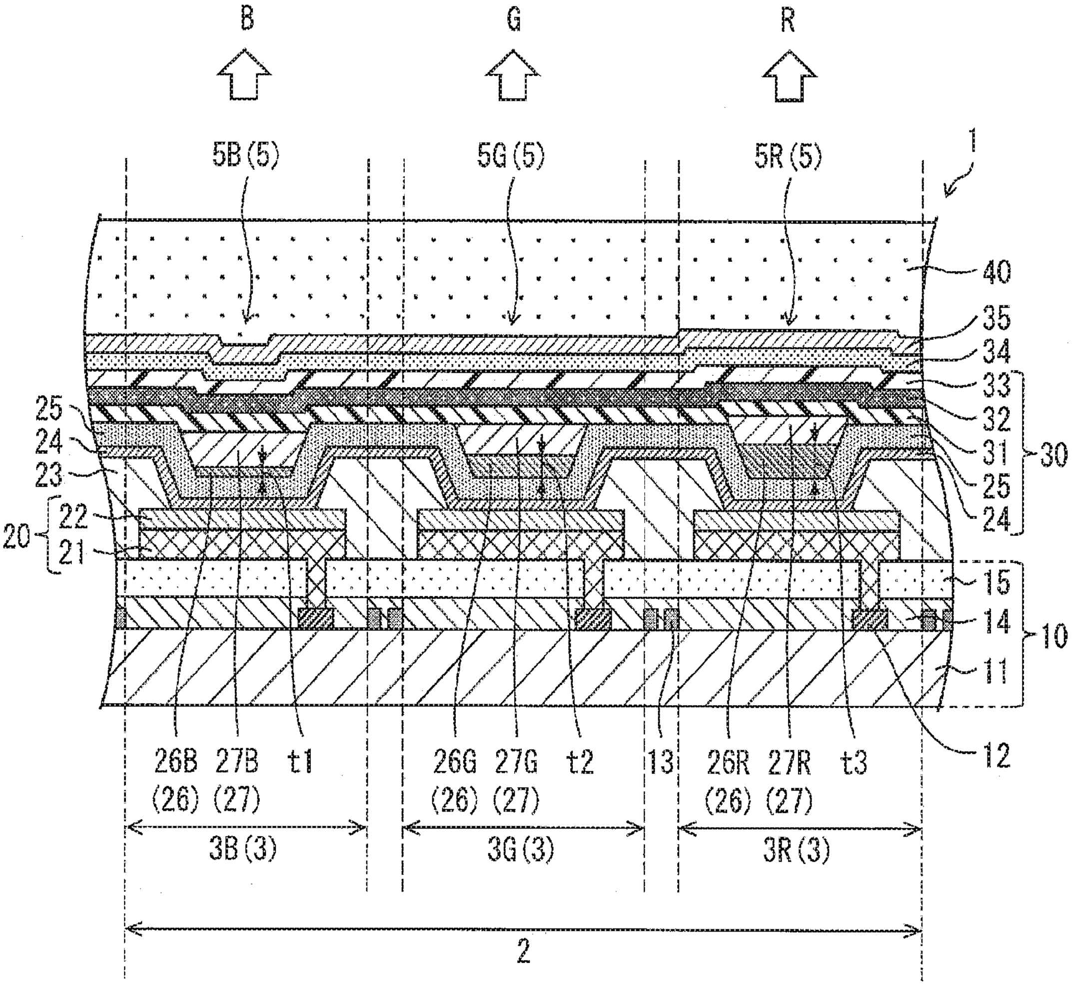

B
G
R
5B(5)
5G(5)
5R(5)
1
40
35
34
33
32
31
30
25
24
25
24
23
22
20
21
15
14
10
11
12
26B (26)
27B (27)
t1
26G (26)
27G (27)
t2
13
26R (26)
27R (27)
t3
3B(3)
3G(3)
3R(3)
2

FIG. 1

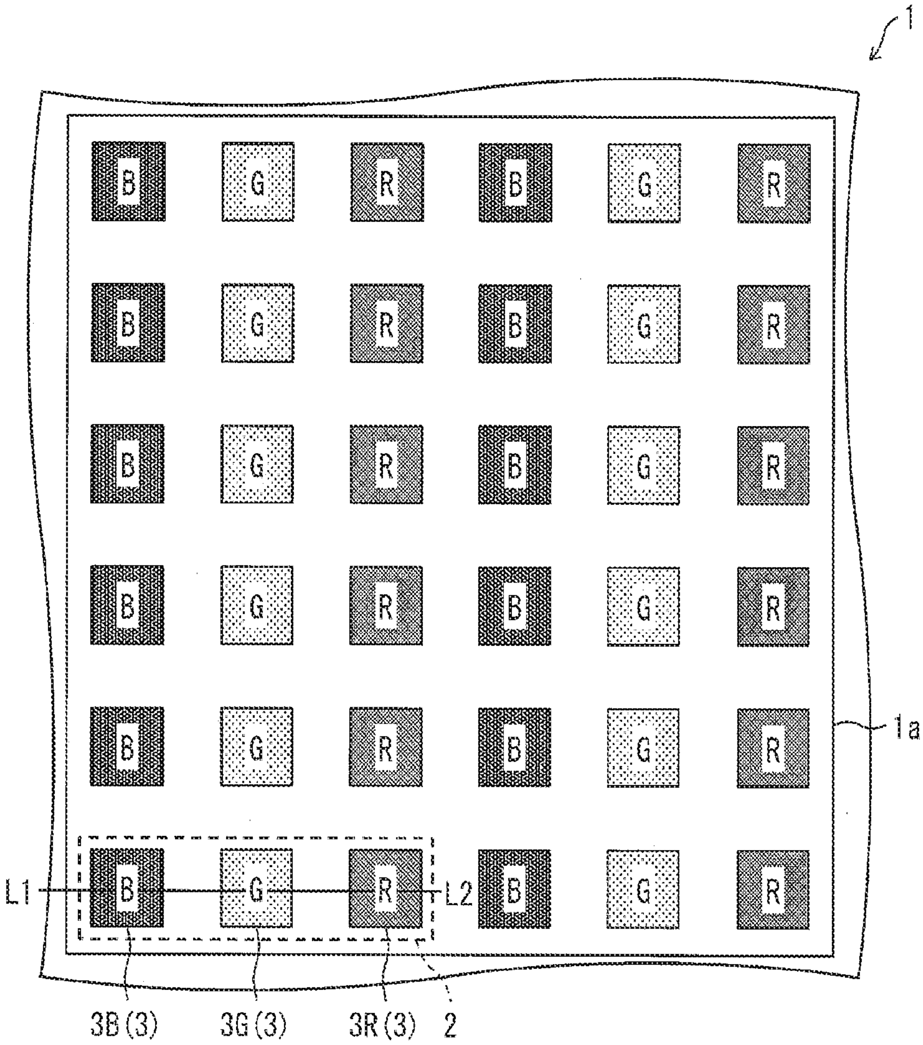


FIG. 2

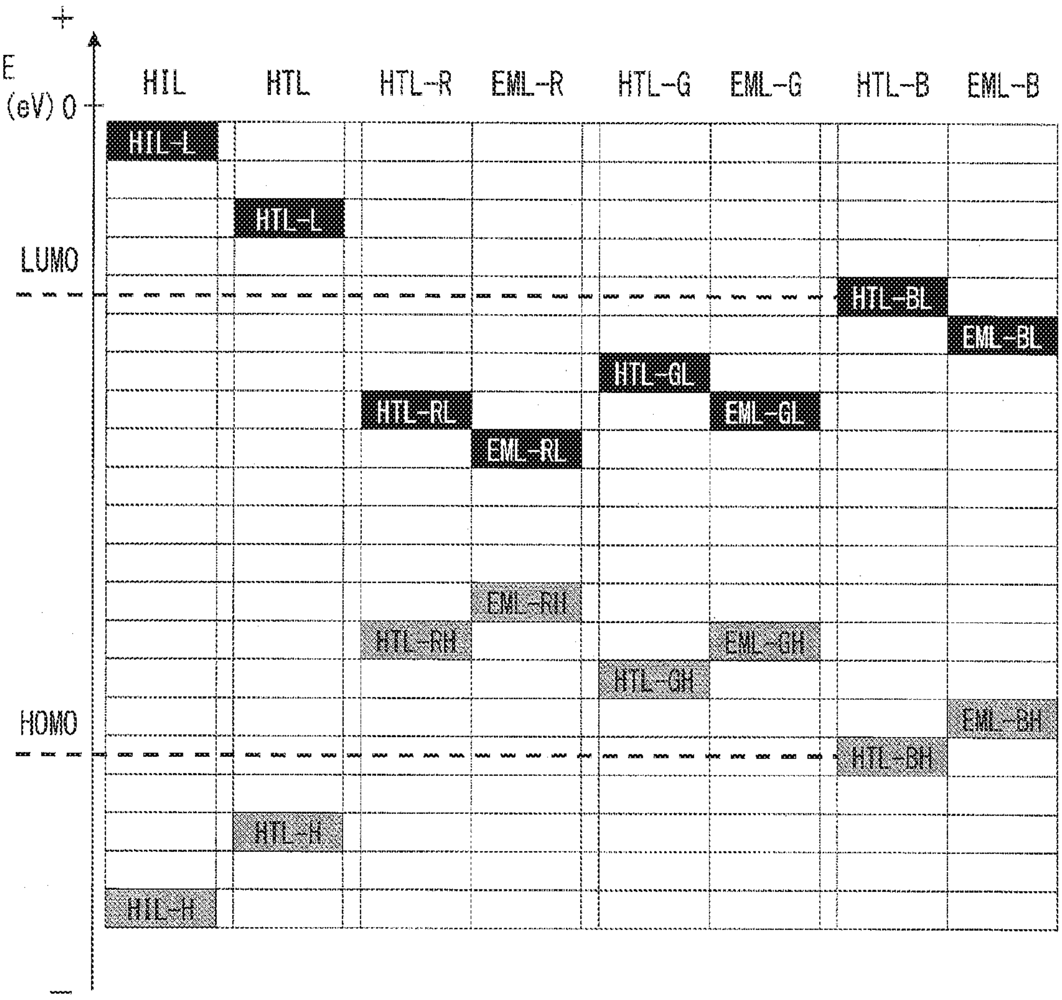

+
E
(eV) 0
HIL
HTL
HTL-R
EML-R
HTL-G
EML-G
HTL-B
EML-B
HIL-L
HTL-L
LUMO
HTL-BL
EML-BL
HTL-GL
HTL-RL
EML-GL
EML-RL
EML-RH
HTL-RH
EML-GH
HTL-GH
HOMO
EML-BH
HTL-BH
HTL-H
HIL-H
−

FIG. 3

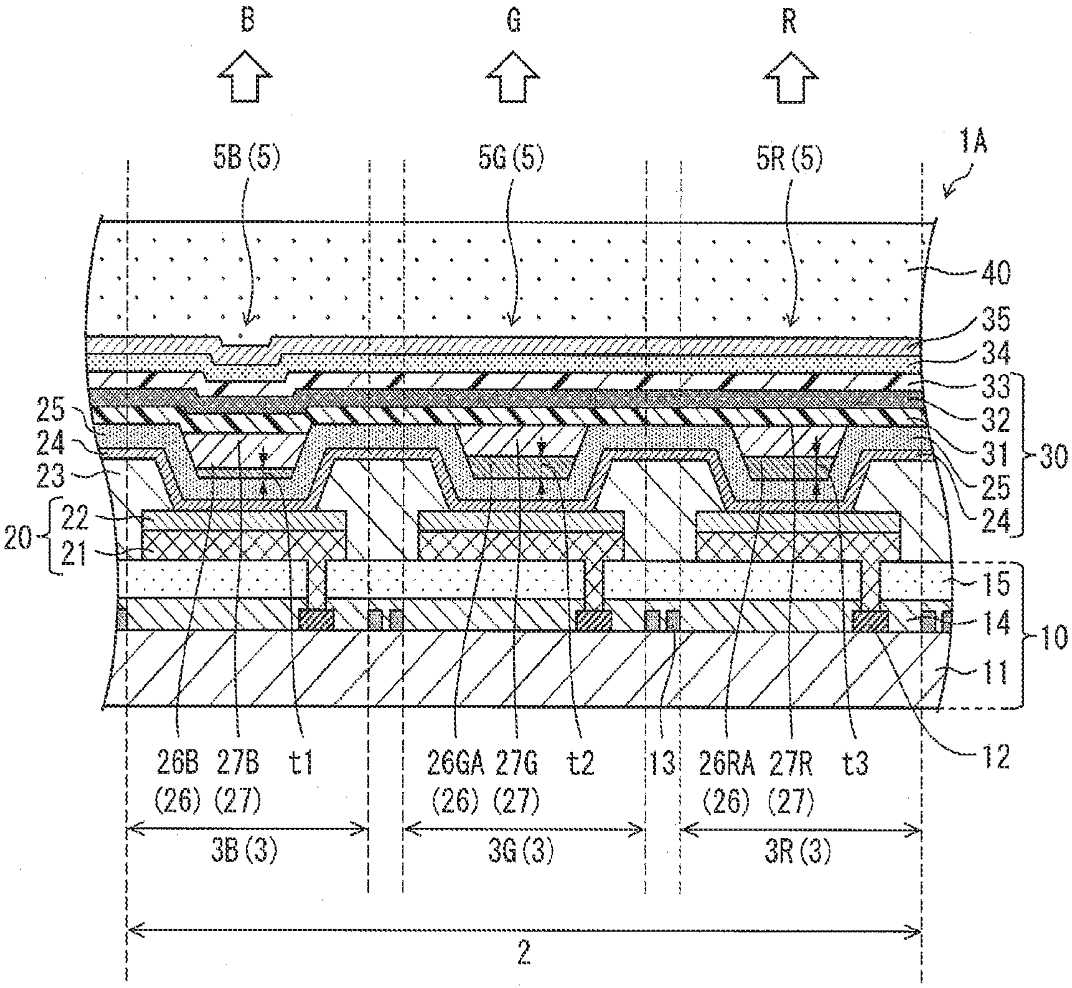

B
G
R
5B (5)
5G (5)
5R (5)
1A
40
35
34
33
32
31
30
25
24
25
24
23
22
21
20
15
14
10
11
12
13
26B (26)
27B (27)
t1
26GA (26)
27G (27)
t2
26RA (26)
27R (27)
t3
3B (3)
3G (3)
3R (3)
2

FIG. 4

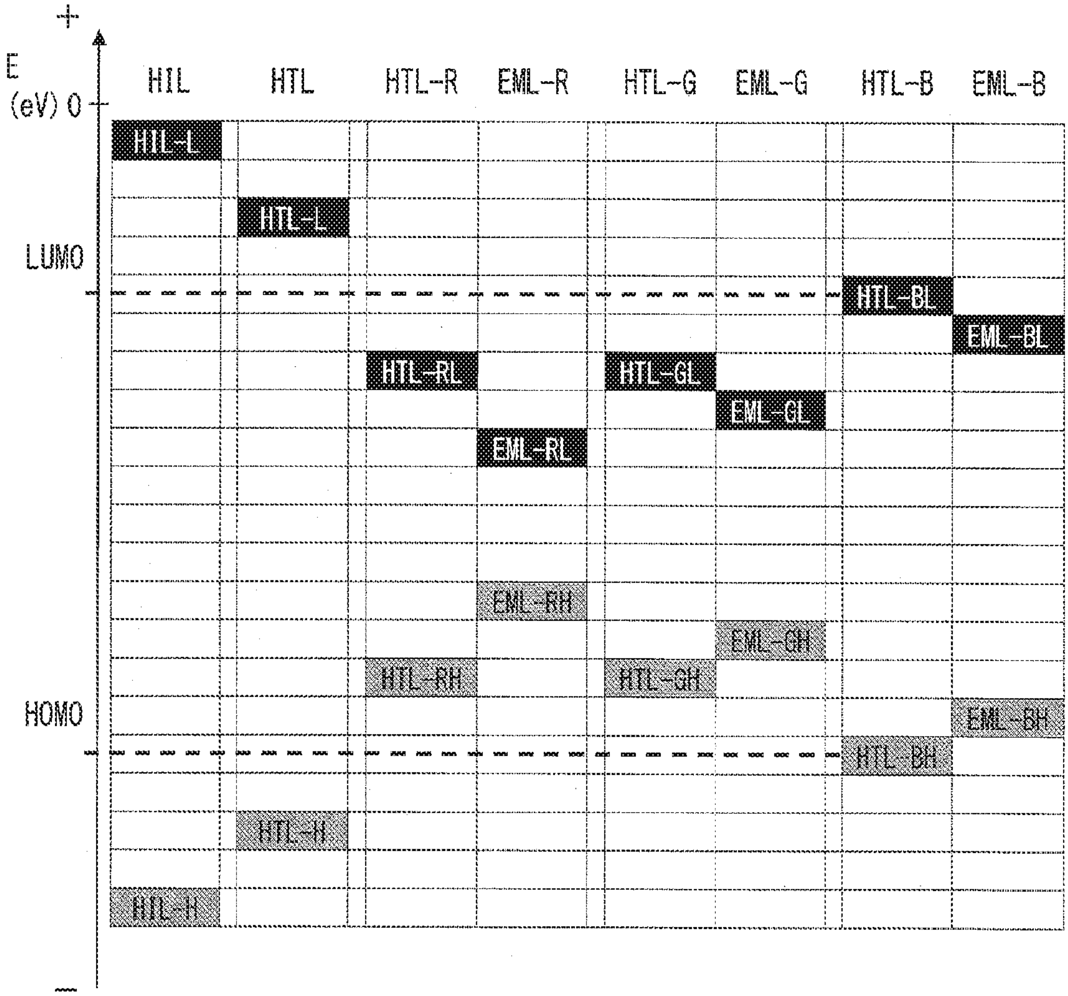

+
E
(eV) 0
HIL
HTL
HTL-R
EML-R
HTL-G
EML-G
HTL-B
EML-B
LUMO
HOMO
HIL-L
HTL-L
HTL-BL
EML-BL
HTL-RL
HTL-GL
EML-GL
EML-RL
EML-RH
EML-GH
HTL-RH
HTL-GH
EML-BH
HTL-BH
HTL-H
HIL-H
-

FIG. 5

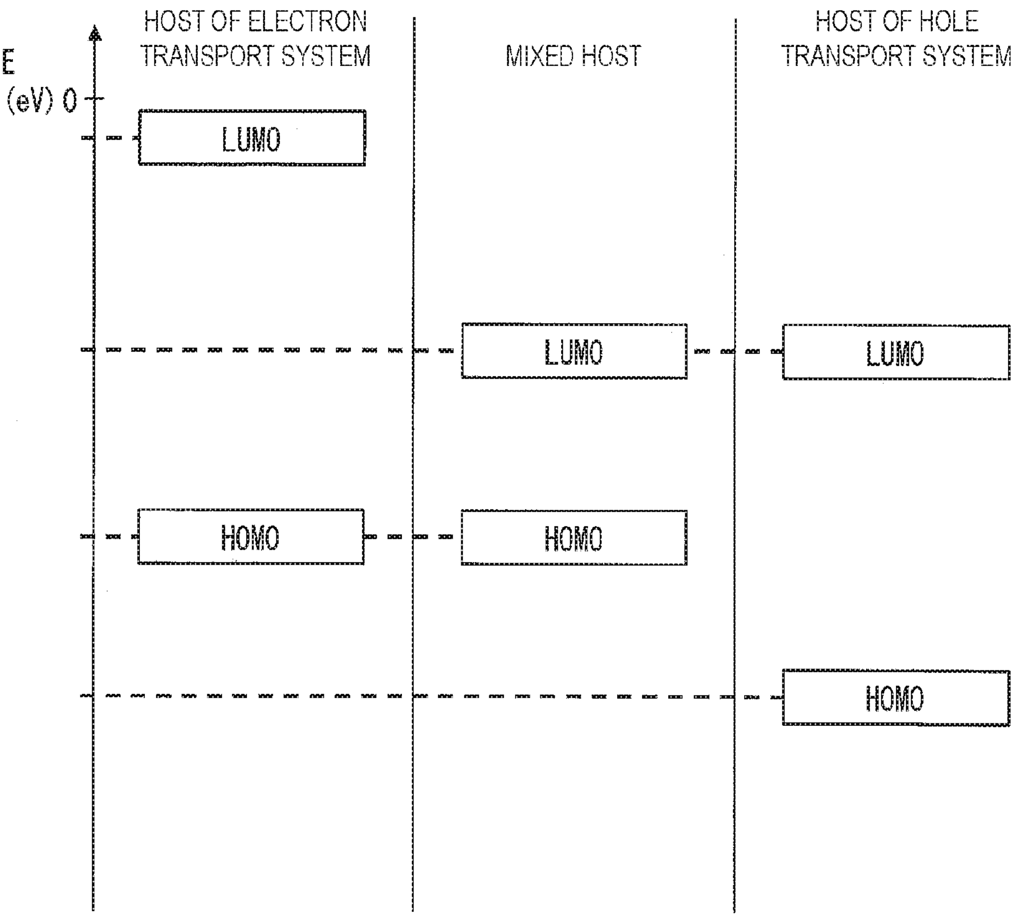

HOST OF ELECTRON TRANSPORT SYSTEM
MIXED HOST
HOST OF HOLE TRANSPORT SYSTEM
E (eV) 0
LUMO
LUMO
LUMO
HOMO
HOMO
HOMO

FIG. 6

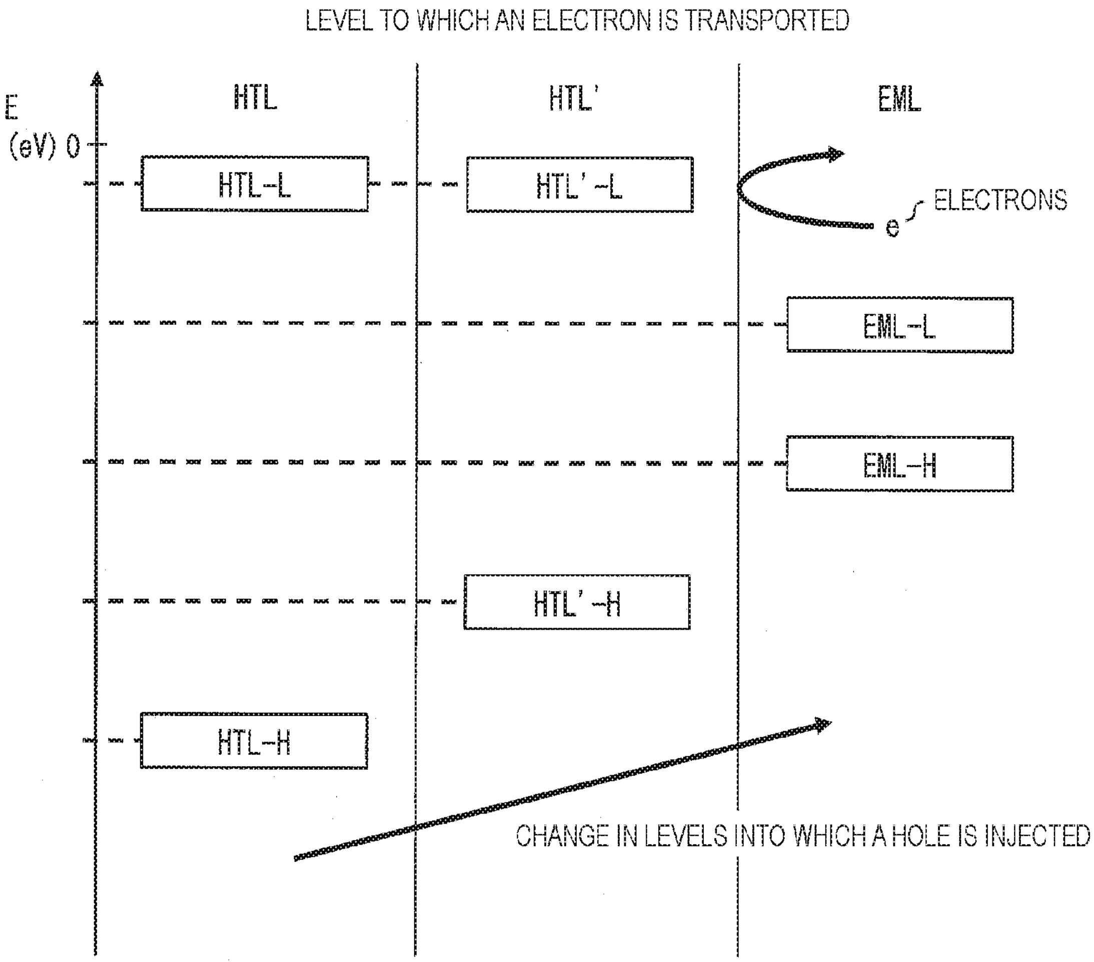

LEVEL TO WHICH AN ELECTRON IS TRANSPORTED
E
(eV) 0
HTL
HTL'
EML
HTL-L
HTL'-L
e
ELECTRONS
EML-L
EML-H
HTL'-H
HTL-H
CHANGE IN LEVELS INTO WHICH A HOLE IS INJECTED

FIG. 7

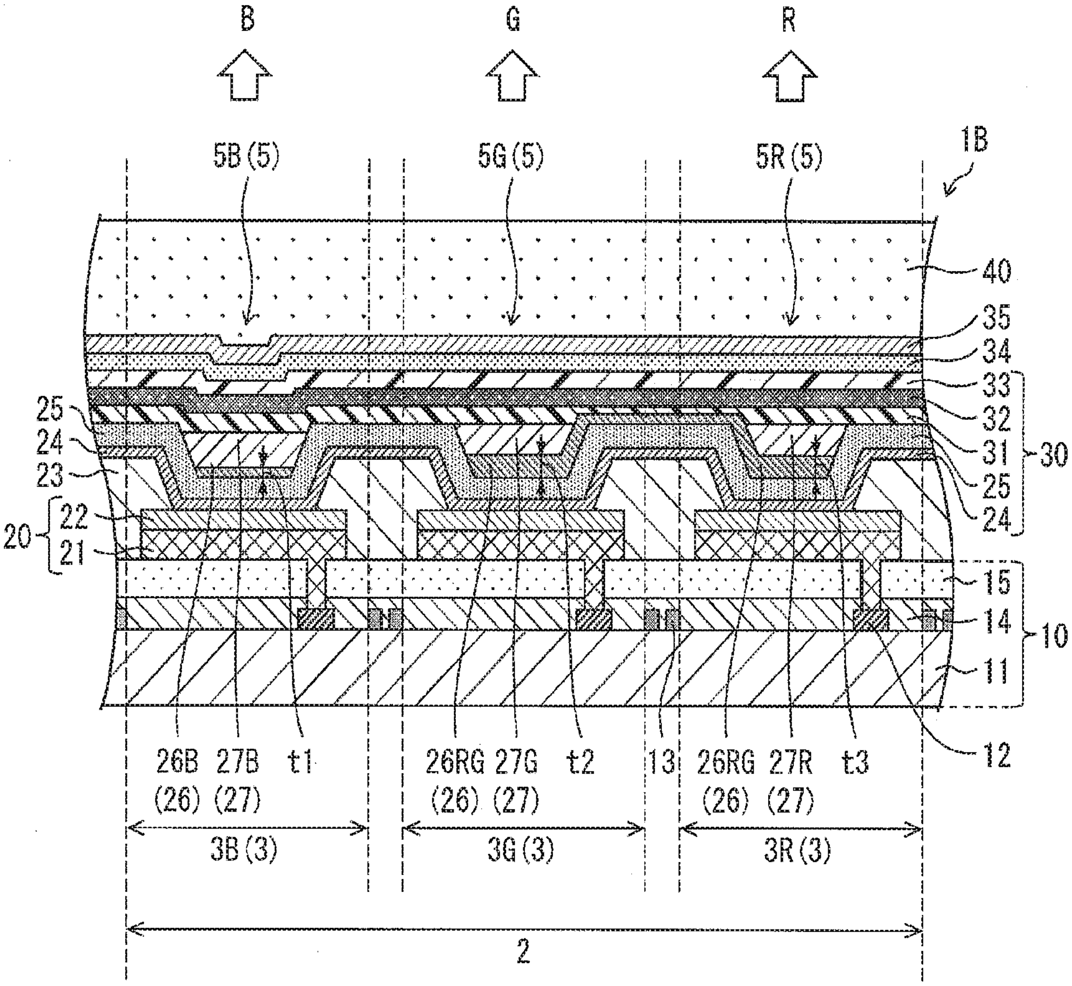

B
G
R
5B (5)
5G (5)
5R (5)
1B
40
35
34
33
32
31
30
25
24
23
22
21
20
15
14
10
11
12
13
26B (26)
27B (27)
t1
26RG (26)
27G (27)
t2
26RG (26)
27R (27)
t3
3B (3)
3G (3)
3R (3)
2

FIG. 8

ORGANIC EL DISPLAY DEVICE

TECHNICAL FIELD

[0001] The disclosure relates to an organic EL display device.

BACKGROUND ART

[0002] PTL 1 describes a configuration including: a light emitting layer individually disposed in each sub pixel; a hole injecting layer common to the sub pixels; and an intermediate layer common to the sub pixels disposed between the light emitting layer and the hole injecting layer. According to PTL 1, this intermediate layer facilitates the adjustment of a variety of band gaps, along with a value of a Lowest Unoccupied Molecular Orbital (LUMO) and a Highest Occupied Molecular Orbital (HOMO).

CITATION LIST

Patent Literature

[0003] PTL 1: JP 2005-183404 A

SUMMARY

Technical Problem

[0004] In a light emitting layer arranged in each sub pixel, at least one of the energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) and the Highest Occupied Molecular Orbital (HOMO) is different for each light emission color.

[0005] Therefore, the mere provision of an intermediate layer common to the sub pixels, as described in PTL 1, may fail to inject a hole efficiently for each light emitting layer in sub pixels. Failure of efficient injection of a hole into the light emitting layer degrades the light emission efficiency of the light emitting layer.

[0006] In view of the typical problem described above, the disclosure is to provide an organic EL display device, wherein a hole can be efficiently injected from a hole injecting layer into a light emitting layer.

Solution to Problem

[0007] In order to solve the problem, in an organic EL display device according to one aspect of the disclosure, pixels including a plurality of sub pixels emitting light of different colors are arranged on a display region in a matrix, the organic EL display device including: a light emitting layer individually disposed in each sub pixel and emitting light of a different color for each sub pixel; a positive electrode and a negative electrode arranged facing each other, the light emitting layer being disposed between the positive electrode and the negative electrode; and a common hole transport layer common to the sub pixel, the common hole transport layer being disposed between the positive electrode and the light emitting layer, wherein an individual hole transport layer is further individually disposed in each sub pixel, between the common hole transport layer and the light emitting layer for each sub pixel, and an energy level value of a lowest unoccupied molecular orbital of the individual hole transport layer is smaller than an energy level value of a lowest unoccupied molecular orbital of the common hole transport layer, and greater than an energy level value of a lowest unoccupied molecular orbital of the light emitting layer in the sub pixels.

Advantageous Effects of the Disclosure

[0008] According to one aspect of the disclosure, the effect of obtaining an organic EL display device can be exerted, wherein a hole can be efficiently injected from a hole injecting layer into a light emitting layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a cross-sectional view illustrating the configuration of an organic EL display device according to Embodiment 1 of the disclosure.

[0010] FIG. **2** is a plan view illustrating the configuration of the organic EL display device according to Embodiment 1 of the disclosure.

[0011] FIG. **3** is a view illustrating a HOMO-LUMO energy gap in a sub pixel of the organic EL display device according to Embodiment 1 of the disclosure.

[0012] FIG. **4** is a cross sectional view illustrating the configuration of an organic EL display device according to Embodiment 2 of the disclosure.

[0013] FIG. **5** is a view illustrating a HOMO-LUMO energy gap in a sub pixel of the organic EL display device according to Embodiment 2 of the disclosure.

[0014] FIG. **6** is a view describing HOMO-LUMO energy gaps in a light emitting layer of the organic EL display device according to Embodiment 1 of the disclosure.

[0015] FIG. **7** is a view describing HOMO-LUMO energy gaps of HTL, HTL', and EML of the organic EL display device according to Embodiment 1 of the disclosure.

[0016] FIG. **8** is a cross-sectional view illustrating the configuration of an organic EL display device according to Embodiment 3 of the disclosure.

DESCRIPTION OF EMBODIMENTS

Embodiment 1

[0017] Embodiment 1 of the disclosure will be described with reference to FIGS. **1** to **3**, **6**, and **7**.

Schematic Configuration of Organic EL Display Device 1

[0018] FIG. **2** is a plan view illustrating the configuration of organic EL display device **1** according to Embodiment 1 of the disclosure. FIG. **1** is a cross-sectional view along line L**1**-L**2** illustrated in FIG. **2**.

[0019] As illustrated in FIG. **2**, the organic EL display device **1** includes a plurality of the pixels **2** arranged on the display region **1***a* in a matrix. Note that in FIG. **2**, for convenience of illustration, the number of the pixels **2** is reduced.

[0020] As illustrated in FIGS. **1** and **2**, each pixel **2** (that is, one pixel) has sub pixels **3** emitting light of different colors. In the present embodiment, each pixel **2** has a red sub pixel **3**R emitting red light, a green sub pixel **3**G emitting green light, and a blue sub pixel **3**B emitting blue light, as sub pixels **3**. As a result, the organic EL display device **1** can display a full color image on the display region **1***a*. Note that as illustrated in FIG. **2**, the organic EL display device **1** according to the present embodiment has a pixel array, in which a red sub pixel **3**R, a green sub pixel **3**G, and a blue sub pixel **3**B are each linearly arranged (in stripes). The arrangement is referred to as an RGB stripe array.

[0021] As illustrated in FIG. 1, each sub pixel 3 includes a light emitting layer 27 that emits light of a different color for each sub pixel 3, as well as a positive electrode 20 and a negative electrode 34 disposed facing each other and the light emitting layer 27 is disposed between the positive electrode 20 and the negative electrode 34 in each sub pixel 3.

[0022] Further, a common hole transport layer 25 common to the sub pixels 3 is disposed between the positive electrode 20 and the light emitting layer 27. In addition, an individual hole transport layer 26 individually disposed in each sub pixel 3 is disposed between the common hole transport layer 25 and the light emitting layer 27 in each sub pixel 3.

[0023] A blue organic EL element 5B serving as an organic EL element 5 with a blue light emission color is disposed in the blue sub pixel 3B, a green organic EL element 5G serving as an organic EL element 5 with a green light emission color is disposed in the green sub pixel 3G, and a red organic EL element 5R serving as an organic EL element 5 with a red light emission color is disposed in the red sub pixel 3R. The organic EL element 5 includes the positive electrode 20, the negative electrode 34, and the organic EL layer 30 including a layer between the positive electrode 20 and the negative electrode 34.

[0024] The organic EL display device 1 includes a configuration, in which the positive electrode 20, an edge cover 23, the organic EL layer 30, the negative electrode 34, a circularly polarized light filter 35, and a sealing layer 40 are formed on a Thin Film Transistor (TFT) substrate 10. The organic EL display device 1 includes a drive circuit (not illustrated) configured to drive each sub pixel 3. The organic EL display device 1 may further have a touch panel on the sealing layer 40.

[0025] The organic EL element 5 of each of the plurality of colors described above is provided on TFT substrate 10.

[0026] The plurality of organic EL elements 5, each of which emits each of these colors, are enclosed between the TFT substrate 10 and the sealing layer 40. The organic EL display device 1 according to the present embodiment is a top emitting display device that emits light from the sealing layer 40 side. Details are described below.

Configuration of TFT Substrate 10

[0027] The TFT substrate 10 is a circuit substrate in which a TFT circuit including the TFT 12 and a wiring line 13 is formed. The TFT substrate 10 includes a configuration, in which the support body 11, the TFT 12 and the wiring line 13, a passivation film 14, and an interlayer insulating film 15 are layered in this order.

[0028] The support body 11 includes a transparent insulating material such as a plastic film or glass substrate.

[0029] The TFT 12 is a driving transistor for supplying a driving current to the organic EL layer 30. The TFT 12 is formed in each sub pixel 3 on the support body 11 or another layer on the support body. While not illustrated, the TFT 12 has a semiconductor layer, a gate electrode, a drain electrode, and a source electrode.

[0030] The wiring line 13 is formed on the support body 11, the wiring line 13 including a gate wiring line connected to the gate electrode of the TFT 12, as well as a source wiring line connected to the source electrode of the TFT 12. When viewed from the direction vertical to the substrate surface of the TFT substrate 10, the gate wiring line and the source wiring line are orthogonally crossed. The region surrounded by the gate wiring line and the source wiring line is the sub pixel 3.

[0031] The light emission intensity of each sub pixel 3 is determined by scanning and selection by the wiring line 13 and the TFT 12. As described above, the organic EL display device 1 selectively emits each organic EL element 5 at the desired luminance using the TFT 12, thereby displaying images.

[0032] The passivation film 14 prevents peeling of the metal film in the TFT 12, thereby protecting the TFT 12. The passivation film 14 is formed on the support body 11 or another layer on the support body 11, to cover the TFT 12. The passivation film 14 is an inorganic insulating film including silicon nitride, silicon oxide, and the like.

[0033] The interlayer insulating film 15 provides a leveled surface over irregularities on the passivation film 14. The interlayer insulating film 15 is formed on the passivation film 14. The interlayer insulating film 15 is an organic insulating film including photosensitive resin such as acryl or polyimide.

Configuration of Organic EL Element 5

[0034] Each organic EL element 5 includes a positive electrode 20, an organic EL layer 30, and a negative electrode 34. The organic EL layer 30 is held between the positive electrode 20 and the negative electrode 34. In the present embodiment, layers provided between the positive electrode 20 and the negative electrode 34 are collectively referred to as an organic EL layer 30. The positive electrode 20, organic EL layer 30, and negative electrode 34 are layered in this order from the TFT substrate 10 side.

[0035] The positive electrode 20 is individually pattern formed in an island shape for each sub pixel 3, with the end of the positive electrode 20 covered by edge cover 23. Each positive electrode 20 is connected to the TFT 12 via contact holes provided in the passivation film 14 and the interlayer insulating film 15.

[0036] The edge cover 23 is disposed to partition the adjacent sub pixels 3. The edge cover 23 is an insulating layer, and for example, includes photosensitive resin. The edge cover 23 is formed to cover the end of the positive electrode 20. The edge cover 23 prevents a short circuit of the negative electrode 34 that may be caused by concentration of the electrodes or a decrease in thickness of the organic EL layer 30 at the end of the positive electrode 20. Moreover, the edge cover 23 also functions as a pixel separation film to prevent current leakage between the adjacent sub pixels 3.

[0037] The negative electrode 34 is a common electrode common to the sub pixels 3. The negative electrode 34 is common to the sub pixels 3 in all pixels 2. However, the present embodiment is not limited thereto, and the negative electrode 34 may be provided for each sub pixel 3 individually.

[0038] The circularly polarized light filter 35 is provided on the negative electrode 34 to cover the negative electrode 34. Additionally, a sealing layer 40 is provided on the circularly polarized light filter 35 to cover the circularly polarized light filter 35. The circularly polarized light filter 35 may be provided as required.

[0039] The sealing layer 40 protects the negative electrode 34 serving as the upper electrode, in addition to preventing external oxygen and moisture from infiltrating into each organic EL element **5**. Note that the sealing layer **40** is provided to cover the negative electrode **34** in all organic EL elements **5**.

Positive Electrode **20** and Negative Electrode **34**

[0040] The positive electrode **20** and the negative electrode **34** are a pair of electrodes. The positive electrode may function as an electrode for injecting holes (h^+) into the organic EL layer **30**. The negative electrode may function as an electrode for injecting electrons (e^+) into the organic EL layer **30**.

[0041] The shape, structure, size, or the like of the positive electrode and the negative electrode are not particularly limited and can be appropriately selected according to the application and object of the organic EL element **5**.

[0042] In the present embodiment, the case will be described as an example in which, as illustrated in FIG. **1**, the positive electrode **20** is patterned and disposed on the TFT substrate **10**, the organic EL layer **30** is disposed between the positive electrode **20** and the negative electrode **34**, and the negative electrode **34** is a negative electrode provided to be common to the sub pixels **3** in all pixels **2**.

[0043] However, the present embodiment is not limited thereto, and the positive electrode **20** may be a negative electrode and the negative electrode **34** may be a positive electrode. In this case, the layering order or carrier mobility (carrier transport property, that is, hole transport property and electron transport property) of each functional layer configuring organic EL layer **30** are reversed. Similarly, the component materials of the positive electrode **20** and negative electrode **34** are also reversed.

[0044] Electrode materials capable of being employed as the positive electrode and the negative electrode are not particularly limited to a specific material, and, for example, known electrode materials may be employed therefor.

[0045] As the positive electrode, for example, metals such as gold (Au), platinum (Pt), and nickel (Ni), transparent electrode materials such as indium tin oxide (ITO), tin oxide (SnO_2), indium zinc oxide (IZO), gallium-added and zinc oxide (GZO) can be utilized.

[0046] The negative electrode preferably includes a material having a minor work function for injecting electrons into the light emitting layer **34**. As the negative electrode, for example, metals such as lithium (Li), calcium (Ca), cerium (Ce), barium (Ba), and aluminum (Al), or alloys such as Ag (silver)-Mg (magnesium) alloy and Al-Li alloy containing these metals can be utilized.

[0047] The thickness of the positive electrode and negative electrode is not limited to a specific thickness, and the thickness capable may be similar to that of known ones.

[0048] The positive electrode **20** includes a configuration including the reflective electrode **21** and the transparent electrode **22** layered in this order from the TFT substrate **10** side. Note that the positive electrode **20** may be a single layer structure including a reflective electrode material.

[0049] Exemplary reflective electrode materials include a black electrode material such as tantalum (Ta) or carbon (C), a reflective metal electrode material such as Al, Ag, gold (Au), Al—Li alloy, Al-neodymium (Nd) alloy, or Al-silicon (Si) alloy.

[0050] As a transparent electrode material, for example, the transparent electrode material described above and the like may be used, and a semi-transparent electrode material may also be used, such as a thin film of Ag.

[0051] The reflective electrode **21** having the same film thickness for each sub pixel **3** is independently formed and is connected to the drain electrode of TFT **12** in each sub pixel **3**.

[0052] The transparent electrode **22** also having the same film thickness for each sub pixel **3** is independently formed. The transparent electrode **22** is formed in each sub pixel **3** by the same manufacturing process.

Organic EL Layer **30**

[0053] The organic EL layer **30** includes a configuration, in which the hole injecting layer **24** (HIL), a common hole transport layer **25** (HTL), blue individual hole transport layer **26**B (HTL-B)/green individual hole transport layer **26**G (HTL-G)/red individual hole transport layer **26**R (HTL-R), blue light emitting layer **27**B (EML-B)/green light emitting layer **27**G (EML-G)/red light emitting layer **27**R (EML-R), a hole shielding layer **31** (HBL), an electron transport layer **32** (ETL), and an electron injecting layer **33** (EIL) are layered, as functional layers, in this order from the positive electrode **20** side.

[0054] In the organic EL display device **1**, optical adjustment is carried out between the positive electrode **20** and the light emitting layer **27**, or between the positive electrode **20** and the negative electrode **34**, for each organic EL element **5**, that is, for each sub pixel **3**. As a result, a high definition image can be displayed. In the present embodiment, optical adjustment is carried out between the positive electrode **20** and the light emitting layer **27**, or between the positive electrode **20** and the negative electrode **34**, by changing the film thickness of the individual hole transport layer **26**, for each organic EL element **5**, that is, for each sub pixel **3**.

[0055] The hole injecting layer **24**, the common hole transport layer **25**, the hole shielding layer **31**, the electron transport layer **32**, and the electron injecting layer **33** are formed as layers common to a plurality of pixels **2** across a plurality of pixels **2**. Therefore, the hole injecting layer **24**, the common hole transport layer **25**, the hole shielding layer **31**, the electron transport layer **32**, and the electron injecting layer **33** are formed so as to be common to the sub pixels **3**B, **3**G, and **3**R.

[0056] Hereinafter, in a case where the blue individual hole transport layer **26**B, the green individual hole transport layer **26**G, and the red individual hole transport layer **26**R need not be discussed separately, the blue individual hole transport layer **26**B, the green individual hole transport layer **26**G, and the red individual hole transport layer **26**R are collectively referred to as the individual hole transport layer **26** (HTL).

[0057] Moreover, in a case where the blue light emitting layer **27**B, the green light emitting layer **27**G, and the red light emitting layer **27**R need not be discussed separately, the blue light emitting layer **27**B, the green light emitting layer **27**G, and the red light emitting layer **27**R are collectively referred to as the light emitting layer **27**.

[0058] The functional layers other than the common hole transport layer **25**, the individual hole transport layer **26**, and the light emitting layer **27** are not essential layers as the organic EL layer **30**, but may be appropriately formed according to the required properties of the organic EL element **5**. Hereinafter, each of the functional layers above will be described.

Hole Injecting Layer **24** (HIL) and Common Hole Transport Layer **25** (HTL)

[0059] The hole injecting layer **24** is a layer including a material having a hole injecting property and a function to enhance the efficiency of hole injection to the light emitting layer **27**. The hole injecting layer **24** is formed on the positive electrode **20** and the edge cover **23** and is common to each sub pixel **3**. Moreover, the common hole transport layer **25** includes a material having a hole transport property and a function to enhance the efficiency of transporting a hole into light emitting layer **27**. The hole is injected from the positive electrode **20** and transported via the hole injecting layer **24** into the common hole transport layer **25**.

[0060] The hole injecting layer **24** and the common hole transport layer **25** may be formed as mutually independent layers or may be integrated together as a hole injection-cum-transport layer. Moreover, both the hole injecting layer **24** and the common hole transport layer **25** need not be provided. Only the common hole transport layer **25** may be provided.

[0061] The known material as mentioned below can be used as the material of the hole injecting layer **24** and the common hole transport layer **25**. Note that as mentioned later, the hole injecting layer **24** and the common hole transport layer **25** are configured such that the common hole transport layer **25** has a smaller HOMO-LUMO energy gap than the hole injecting layer **24**. Note that this HOMO-LUMO energy gap will be mentioned later using FIG. **3**.

[0062] Exemplary component materials of the hole injecting layer **24** and the common hole transport layer **25** include chain or heterocyclic conjugated monomers, oligomers, or polymers, such as naphthalene, anthracene, azatriphenylene, fluorenone, hydrazone, stilbene, triphenylene, benzine, styrylamine, triphenylamine, porphyrin, triazole, imidazole, oxadiazole, oxazole, polyaryl alkane, phenylenediamine, aryl amine, and derivatives thereof, a thiophene based compound, a polysilane based compound, a vinyl carbazole based compound, and an aniline based compound. More specifically, for example, N,N'-di(naphthalene-1-yl)-N,N'-diphenyl-benzidine (α-NPD), 2,3,6,7,10,11-hexacyano-1,4,5,8,9,12-hexaazatriphenylene (HAT-CN), 1,3-bis(carbazole-9-yl)benzene (mCP), di[4-(N,N-ditolyl-amino)-phenyl]cyclohexane (TAPC), 9,10-diphenylanthracene-2-sulfonate (DPAS), N,N'-diphenyl-N,N'-(4-(di(3-tolyl)amino)phenyl)-1,1'-biphenyl-4,4'-diamine (DNTPD), iridium(III)tris[N,N'-diphenylbenzoimidazole-2-ylidene-C2,C2'](Ir(dpbic)3), 4,4',4"-tris-(N-carbazolyl)-triphenylamine (TCTA), 2,2-bis(p-trimellitic oxyphenyl)propanoic anhydride (BTPD), bis[4-(p,p-ditolylamino)phenyl]diphenylsilane (DTASi), or the like, are used.

[0063] Note that the hole injecting layer **24** and the common hole transport layer **25** may be an intrinsic material having a hole injecting property or an intrinsic material having a hole transport property, in which an impurity is not doped; alternatively, an impurity may be doped to increase the electrical conductivity, etc.

Electron Transport Layer **32** and Electron Injecting Layer **33**

[0064] The electron injecting layer **33** is a layer including a material with an electron injecting property and a function to enhance the efficiency of electron injection to the light emitting layer **27**. Moreover, the electron transport layer **32** is a layer including a material having an electron transport property and a function to enhance the efficiency of electron transport to the light emitting layer **27**.

[0065] The electron injecting layer **33** and the electron transport layer **32** are formed to be common to each sub pixel **3**. The electron transport layer **32** is formed on each of the light emitting layer **27** and the common hole transport layer **25**. The electron injecting layer **33** is formed on the electron transport layer **32**.

[0066] Note that the electron injecting layer **33** and the electron transport layer **32** may be formed as mutually independent layers or may be integrated together as an electron injection-cum-transport layer. Moreover, both the electron injecting layer **33** and the electron transport layer **32** need not be provided. Only one of them, for example, only the electron transport layer **32** may be provided. Neither the electron injecting layer **33** nor the electron transport layer **32** may be provided.

[0067] The electron injecting layer **33** and the electron transport layer **32** may include known materials.

[0068] Exemplary component materials of electron injecting layer **33** and electron transport layer **32** include quinoline, perylene, phenanthroline, bisstyryl, pyrazine, triazole, oxazole, oxadiazole, fluorenone, derivatives and metal complexes thereof, lithium fluoride (LiF), etc.

[0069] More specific examples thereof include bis[(2-diphenylphosphoryl)phenyl]ether (DPEPO), 4,7-diphenyl-1,10-phenanthroline (Bphen), 3,3'-bis(9H-carbazole-9-yl)biphenyl (mCBP), 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 1,3,5-tris(N-phenylbenzoimidazole-2-yl)benzene (TPBI), 3-phenyl-4(1'-naphthyl)-5-phenyl-1,2,4-triazole (TAZ), 1,10-phenanthroline, Alq(tris(8-hydroxyquinoline)aluminum), LiF, etc.

Sealing Layer **40**

[0070] The sealing layer **40** is formed on the circularly polarized light filter **35**. The sealing layer **40** seals the entire surface of the display region. The sealing layer **40** is employed for thin film sealing (TFE: Thin Film Encapsulation) on the organic EL layer **30**, and thus the organic EL layer **30** is prevented from being deteriorated by moisture and oxygen infiltrated from outside.

[0071] As one example, the sealing layer **40** may have a three layer structure, in which an inorganic layer, an organic layer, and an inorganic layer are layered in this order. Examples of a material for the organic layer include organic insulating materials (resin materials) such as a polysiloxane, silicon oxide carbide (SiOC), an acrylate, a polyurea, parylene, a polyimide, and a polyamide. Examples of a material for the inorganic layer include inorganic insulating materials such as silicon nitride, silicon oxide, silicon oxynitride, and Al_2O_3. Note that the structure of the sealing layer **40** is not limited to the three layer structure described above.

Individual Hole Transport Layer **26** and Light Emitting Layer **27**

[0072] In each sub pixel **3**, the island shaped individual hole transport layer **26** is formed on the common hole transport layer **25**, while the light emitting layer **27** is formed on the individual hole transport layer **26**.

[0073] In the blue sub pixel **3**B, the blue individual hole transport layer **26**B serving as the individual hole transport layer **26** is formed on the common hole transport layer **25**, while the blue light emitting layer **27**B emitting blue light is formed on the blue individual hole transport layer **26**B. In the green sub pixel **3**G, the green individual hole transport layer **26**G serving as the individual hole transport layer **26** is formed on the common hole transport layer **25**, while the green light emitting layer **27**G emitting green light is formed on the green individual hole transport layer **26**G. In the red sub pixel **3**R, the red individual hole transport layer **26**R serving as the individual hole transport layer **26** is formed on the common hole transport layer **25**, while the red light emitting layer **27**R emitting red light is formed on the red individual hole transport layer **26**R.

[0074] A hole injected from the positive electrode **20** into the light emitting layer **27**, as well as an electron injected from the negative electrode **34** into the light emitting layer **27**, are recombined in the light emitting layer **27** to form an exciton. The formed exciton emits light during decay from the excited state to the ground state. As a result, the blue light emitting layer **27**B emits blue light, the green light emitting layer **27**G emits green light, and the red light emitting layer **27**R emits red light.

[0075] Here, the energy required for this recombination is different among the blue light emitting layer **27**B, the green light emitting layer **27**G, and the red light emitting layer **27**R. Therefore, with the mere provision of the common hole transport layer **25** common to the blue light emitting layer **27**B, the green light emitting layer **27**G, and the red light emitting layer **27**R, a hole cannot be injected according to each independent material and property of the blue light emitting layer **27**B, the green light emitting layer **27**G, and the red light emitting layer **27**R.

[0076] A hole not injected into the light emitting layer **27** may remain in the common hole transport layer **25**. Thus, the electron is prevented from recombining in the light emitting layer **27**, and the amount of the electrons injected from the electron transport layer **32** into the light emitting layer **27** decreases, with excess electrons remaining in electron transport layer **32**.

[0077] Then, in the organic EL display device **1** according to the present embodiment, the individual hole transport layer **26**, in addition to the common hole transport layer **25**, is further individually formed between the common hole transport layer **25** and the light emitting layer **27** in each sub pixel **3**.

[0078] FIG. **3** is a view illustrating a HOMO-LUMO energy gap in a sub pixel of the organic EL display device according to Embodiment 1 of the disclosure. Each energy level value illustrated in FIG. **3** is defined as follows. Note that in the present embodiment, each energy level value is a negative value.

[0079] The energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) of the hole injecting layer **24** (HIL) is defined as HIL-L, while the energy level value of the Highest Occupied Molecular Orbital (HOMO) thereof is defined as HIL-H.

[0080] The energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) of the common hole transport layer **25** (HTL) is defined as HTL-L, while the energy level value of the Highest Occupied Molecular Orbital (HOMO) thereof is defined as HTL-H.

[0081] The energy level value of the lowest unoccupied molecular orbital (LUMO) of the red individual hole transport layer **26**R (HTL-R) is defined as HTL-RL, while the energy level value of the highest occupied molecular orbital (HOMO) thereof is defined as HTL-RH.

[0082] The energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) of the red light emitting layer **27**R (EML-R) is defined as EML-RL, while the energy level value of the Highest Occupied Molecular Orbital (HOMO) is defined as EML-RH.

[0083] The energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) of the green individual hole transport layer **26**G (HTL-G) is defined as HTL-GL, while the energy level value of the Highest Occupied Molecular Orbital (HOMO) thereof is defined as HTL-GH.

[0084] The energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) of the green light emitting layer **27**G (EML-G) is defined as EML-GL, while the energy level value of the Highest Occupied Molecular Orbital (HOMO) thereof is defined as EML-GH.

[0085] The energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) of the blue individual hole transport layer **26**B (HTL-B) is defined as HTL-BL, while the energy level value of the Highest Occupied Molecular Orbital (HOMO) thereof is defined as HTL-BH.

[0086] The energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) of the blue light emitting layer **27**B (EML-B) is defined as EML-BL, while the energy level value of the Highest Occupied Molecular Orbital (HOMO) thereof is defined as EML-BH.

[0087] Moreover, the difference between the energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) and the energy level value of the Highest Occupied Molecular Orbital (HOMO) is referred to as a HOMO-LUMO energy gap.

[0088] Regarding HIL and HTL, the value of HTL-L is smaller than that of HIL-L, while the value of HTL-H is larger than that of HIL-H. HTL has a smaller HOMO-LUMO energy gap than HIL.

[0089] Regarding HTL and EML-B, the value of EML-BL is smaller than that of HTL-L, while the value of EML-BH is larger than that of HTL-H. EML-B has a smaller HOMO-LUMO energy gap than HTL.

[0090] Regarding EML-B and EML-G, the value of EML-GL is smaller than that of EML-BL, while the value of EML-GH is larger than that of EML-BH. EML-G has a smaller HOMO-LUMO energy gap than EML-B.

[0091] Regarding EML-G and EML-R, the value of EML-RL is smaller than that of EML-GL, while the value of EML-RH is larger than that of HTL-GH. EML-R has a smaller HOMO-LUMO energy gap than EML-G.

[0092] Additionally, the individual hole transport layer **26** formed in each sub pixel **3** is configured as follows.

[0093] Regarding HTL-B, HTL-BL is larger than EML-BL but smaller than HIL-L, while HTL-BH is smaller than EML-BH but larger than HIL-H.

[0094] Regarding HTL-G, HTL-GL is larger than EML-GL but smaller than HTL-BL, while HTL-GH is smaller than EML-GH but larger than HIL-BH.

[0095] Regarding HTL-R, HTL-RL is larger than EML-RL but smaller than HTL-GL, while HTL-RH is smaller than EML-RH but larger than HIL-GH.

[0096] The relationships among HOMOs can be represented as follows.

$$|HIL\text{-}H|>|HTL\text{-}H|>|HTL\text{-}BH|>|EML\text{-}BH|>|HTL\text{-}GH|>|EML\text{-}GH|>|HTL\text{-}RH|>|EML\text{-}RH| \quad \text{(Relationship 1)}$$

[0097] The relationships among LUMOs can be represented as follows.

|HIL-L|<|HTL-L|<|HTL-BL|<|EML-BL|<|HTL-GL|<|EML-GL|<|HTL-RL|<|EML-RL| (Relationship 2)

[0098] In the organic EL display device **1**, the individual hole transport layer **26** is formed to satisfy Relationships (1) and (2) above.

[0099] As described above, the energy level value (HTL-BL, HTL-GL, HTL-RL) of the lowest unoccupied molecular orbital (LUMO) of the individual hole transport layer **26** is smaller than the energy level value (HTL-L) of the lowest unoccupied molecular orbital (LUMO) of the common hole transport layer **25**, but larger than the energy level value (EML-BL, EML-GL, EML-RL) of the lowest unoccupied molecular orbital (LUMO) of the light emitting layers **27**B, **27**G, and **27**R in the sub pixel **3**.

[0100] As a result, in each sub pixel **3**, the individual hole transport layer **26** is individually disposed, wherein the energy level value of the lowest unoccupied molecular orbital (LUMO) is smaller than the energy level value of the lowest unoccupied molecular orbital (LUMO) of the common hole transport layer **25**, but larger than the energy level value of the lowest unoccupied molecular orbital (LUMO) of the light emitting layer **27** in the sub pixel **3**. As a result, a hole can be efficiently injected into the light emitting layer **27** for each sub pixel **3**. Consequently, the light emitting layer **27** can be efficiently emitted for each sub pixel **3**.

[0101] Additionally, in each sub pixel **3**, the energy level value (HIL-BH, HIL-GH, HIL-RH) of the highest occupied molecular orbital (HOMO) of the individual hole transport layer **26** is larger than the energy level value (HTL-H) of the highest occupied molecular orbital (HOMO) of the common hole transport layer **25**, but smaller than the energy level value (EML-BH, EML-GH, EML-RH) of the highest occupied molecular orbital (HOMO) of the light emitting layers **27**B, **27**G, and **27**R in the sub pixel **3**. As a result, a hole can be efficiently injected into the light emitting layer **27** for each sub pixel **3**. Therefore, the light emitting layer **27** can be efficiently emitted for each sub pixel **3**.

[0102] Moreover, the HOMO-LUMO energy gap of the blue individual hole transport layer **26**B is largest among the individual hole transport layers **26** disposed in the sub pixel **3** in the pixel **2**.

[0103] Specifically, because the HOMO-LUMO energy gap of the blue individual hole transport layer **26**B is larger than the HOMO-LUMO energy gap of each of the green individual hole transport layer **26**G and the red individual hole transport layer **26**R, a hole can be efficiently injected into the blue light emitting layer **27**B.

[0104] Further, the HOMO-LUMO energy gap of the red individual hole transport layer **26**R is smallest among the individual hole transport layers **26** disposed in the sub pixel **3** in the pixel **2**.

[0105] Specifically, because the HOMO-LUMO energy gap of the red individual hole transport layer **26**R is smaller than the HOMO-LUMO energy gap of the green individual hole transport layer **26**G, a hole can be efficiently injected into each of the red light emitting layer **27**R and the blue light emitting layer **27**B.

[0106] Additionally, the HOMO-LUMO energy gap of the green individual hole transport layer **26**G is larger than the HOMO-LUMO energy gap of the red individual hole transport layer **26**R, but smaller than the HOMO-LUMO energy gap of the blue individual hole transport layer **26**B. As a result, a hole can be efficiently injected into the green light emitting layer **27**G.

[0107] In addition, a film thickness t**1** of the blue individual hole transport layer **26**B is thinnest among the individual hole transport layers **26** disposed in the sub pixel **3** in the pixel **2**.

[0108] Specifically, because the film thickness t**1** of the blue individual hole transport layer **26**B is thinnest among the film thickness t**1** of the blue individual hole transport layer **26**B, the film thickness t**2** of the green individual hole transport layer **26**G, and the film thickness t**3** of the red individual hole transport layer **26**R, the blue light emitting layer **27**B can efficiently emit light.

[0109] Further, the film thickness t**3** of the red individual hole transport layer **26**R is thickest among the individual hole transport layers **26** disposed in the sub pixel **3** in the pixel **2**.

[0110] Specifically, because the film thickness t**3** of the red individual hole transport layer **26**R is thicker than the film thickness t**2** of the green individual hole transport layer **26**G, both the green light emitting layer **27**G and the red light emitting layer **27**R can efficiently emit light.

[0111] Additionally, the film thickness t**2** of the green individual hole transport layer **26**G is thinner than the film thickness t**3** of the red individual hole transport layer **26**R, but thicker than the film thickness t**1** of the blue individual hole transport layer **26**B. As a result, a hole can be efficiently injected into the green light emitting layer **27**G.

[0112] After forming the common hole transport layer **25**, this individual hole transport layer **26** can be patterned in each sub pixel **3** by vapor deposition by color. That is, the individual hole transport layer **26** is individually sequentially patterned in each sub pixel **3**B, **3**G, and **3**R using a mask.

[0113] Note that the configuration is not preferable in which, among the common hole transport layer **25** and the individual hole transport layer **26**, the common hole transport layer **25** is omitted, while only the individual hole transport layer **26** is provided. This is because the individual hole transport layers **26** need to be sequentially patterned for thee colors, and the time required to pattern the common hole transport layer **25** is as three times as long. Thus, the production efficiency may degrade.

[0114] Examples of the materials for the light emitting layer **27** and the individual hole transport layer **26** include the following and they can satisfy Relationships (**1**) and (**2**) above.

[0115] Examples of the blue individual hole transport layer **26**B may include HAT-CN, and CuPc.

[0116] Examples of the green individual hole transport layer **26**G may include a-NPD.

[0117] Examples of the red individual hole transport layer **26**R may include PCzPA.

[0118] Examples of the blue light emitting layer **27**B may include TAPC, and TAZ.

[0119] Examples of the green light emitting layer **27**G may include α-NPD, and BCP.

[0120] Examples of the red light emitting layer **27**R may include TPD, and TPBI.

[0121] Moreover, the film thickness t**1** of the blue individual hole transport layer **26**B may be approximately 10 nm, for example. The film thickness t**2** of the green individual hole transport layer **26**G may be approximately 50 nm, for example. The film thickness t3 of the red individual hole transport layer 26R may be approximately 100 nm, for example.

[0122] FIG. 6 is a view describing a HOMO-LUMO energy gap in a light emitting layer of the organic EL display device according to Embodiment 1 of the disclosure.

[0123] A mixed host obtained by mixing the host material of a hole transport system with the host material of an electron transport system, as illustrated in FIG. 6, has a small energy level value of the lowest unoccupied molecular orbital (LUMO), but has a large energy level value of the highest occupied molecular orbital (HOMO). That is, by mixing the host material of the hole transport system with the host material of the electron transport system, a mixed host having a small HOMO-LUMO energy gap can be obtained. Such a mixed host can be included in light emitting layer 27, and the light emitting layer 27 having a small HOMO-LUMO energy gap can be obtained. As a result, the light emitting layer 27 satisfying Relationships (1) and (2) can be easily obtained.

[0124] Examples of the host materials of such a transport system may include α-NPD. Moreover, examples of the host materials of such an electron transport system may include BCP.

[0125] Note that the mixed host need not be included in all the light emitting layers of the red light emitting layer 27R, the green light emitting layer 27G, and the blue light emitting layer 27B. For example, a configuration may be used in which each of the red light emitting layer 27R and the green light emitting layer 27G includes the mixed host, while the blue light emitting layer 27B does not include the mixed host.

[0126] FIG. 7 is a view describing a HOMO-LUMO energy gap of HTL, HTL', and EML of the organic EL display device 1 according to Embodiment 1 of the disclosure.

[0127] The energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) of the individual hole transport layer 26 (HTL') is defined as HTL'-L, while the energy level value of the Highest Occupied Molecular Orbital (HOMO) of the individual hole transport layer 26 (HTL') is defined as HTL'-H.

[0128] The energy level value of the Lowest Unoccupied Molecular Orbital (LUMO) of the light emitting layer 27 (EML) is defined as EML-L, while the energy level value of the Highest Occupied Molecular Orbital (HOMO) of the light emitting layer 27 (EML) is defined as EML-H.

[0129] It is not problematic as long as the individual hole transport layer 26 (HTL') can prevent an electron from entering from the light emitting layer 27 (EML) into the hole transport layer 26 (HTL).

[0130] Therefore, HTL-L≥HTL'-L is acceptable.

[0131] Moreover, any value of HTL'-L is acceptable as long as the value od HTL'-L satisfies the relationship HTL-L>>EML-L.

Embodiment 2

[0132] A following description is regarding Embodiment 2 of the disclosure, with reference to FIGS. 4 and 5. Note that for convenience of description, members having the same function as the members stated in Embodiment 1 are appended with the same reference symbols, with the description thereof omitted.

[0133] FIG. 4 is a cross-sectional view illustrating the configuration of the organic EL display device 1A according to Embodiment 2 of the disclosure.

[0134] The organic EL display device 1A is configured such that, in the organic EL display device 1 (see FIG. 1), the green individual hole transport layer 26G is replaced with the green individual hole transport layer 26GA, while the red individual hole transport layer 26R is replaced with the red individual hole transport layer 26RA. The configurations of the other parts of the organic EL display device 1A are the same as those of the organic EL display device 1.

[0135] FIG. 5 is a view illustrating a HOMO-LUMO energy gap in the sub pixel of the organic EL display device according to Embodiment 2 of the disclosure.

[0136] As illustrated in FIGS. 4 and 5, the organic EL display device 1A is configured to satisfy Relationships (3) and (4) below.

[0137] That is, the relationships among HOMOs can be represented as follows.

$$|HIL\text{-}H|>|HTL\text{-}H|>|HTL\text{-}BH|>|EML\text{-}BH|>|HTL\text{-}GH|=|HTL\text{-}RH|>|EML\text{-}GH|>|EML\text{-}RH| \quad \text{(Relationship 3)}$$

[0138] The relationships among LUMOs can be represented as follows.

$$|HIL\text{-}L|<|HTL\text{-}L|<|HTL\text{-}BL|<|EML\text{-}BL|<|HTL\text{-}GL|=|HTL\text{-}RL|<|EML\text{-}GL|<|EML\text{-}RL| \quad \text{(Relationship 4)}$$

[0139] As described above, the HOMO-LUMO energy gap of the red individual hole transport layer 26RA is equal to the HOMO-LUMO energy gap of the green individual hole transport layer 26GA.

[0140] Moreover, the film thickness t2 of the green individual hole transport layer 26GA is equal to the film thickness t3 of the red individual hole transport layer 26RA.

[0141] As a result, the red individual hole transport layer 26R and the green individual hole transport layer 26G can include the same material. As a result, the production efficiency can be improved.

[0142] Exemplary materials of the green individual hole transport layer 26GA may include CuPc, and TPD.

[0143] Exemplary materials of the red individual hole transport layer 26RA may include TAPC, and α-NPD.

Embodiment 3

[0144] A following description is regarding Embodiment 3 of the disclosure, with reference to FIG. 8. Note that for convenience of description, members having the same function as the members stated in Embodiments 1 and 2 are appended with the same reference symbols, with the description thereof omitted.

[0145] FIG. 8 is a cross sectional view illustrating the configuration of the organic EL display device 1B according to Embodiment 3 of the disclosure.

[0146] The organic EL display device 1B is configured such that, in the organic EL display device 1A (see FIG. 4), the green individual hole transport layer 26GA and the red individual hole transport layer 26RA are replaced with the common individual hole transport layer 26RG. The configurations of the other parts of the organic EL display device 1B are the same as those of the organic EL display device 1A.

[0147] The common individual hole transport layer 26RG is the individual hole transport layer 26 disposed across the green sub pixel 3G and the red sub pixel 3R to be common to the green sub pixel 3G and the red sub pixel 3R, excluding the blue sub pixel 3B, among the plurality of sub pixels 3.

Note that as the individual hole transport layer **26**, the blue individual hole transport layer **26**B different from the common individual hole transport layer **26**RG is disposed in the blue sub pixel **3**B.

[0148] The common individual hole transport layer **26**RG has a larger HOMO-LUMO energy gap than a light emitting layer which has the largest HOMO-LUMO energy gap among the light emitting layers included in the plurality of sub pixels, in which the common individual hole transport layer **26**RG is disposed. In the present embodiment, the common individual hole transport layer **26**RG is configured such that the LUMO has a larger energy level value than LUMO of EML-GL, while the HOMO has a smaller energy level value than HOMO of EML-GH.

[0149] The film thickness t**2** of the common individual hole transport layer **26**RG disposed in the green sub pixel **3**G is equal to the film thickness t**3** of the common individual hole transport layer **26**RG disposed in the red sub pixel **3**R.

[0150] According to the configuration above, the individual hole transport layer disposed in the other sub pixels described above can include the same material. As a result, the production efficiency can be improved.

[0151] Note that the film thicknesses t**2** and t**3** are larger than the film thickness t**1** of the blue individual hole transport layer **26**B.

Supplement

[0152] In the organic EL display devices **1** and **1**A according to the first aspect of the disclosure, the pixels **2** having a plurality of sub pixels **3** emitting light of different colors are arranged on the display region **1** in a matrix, the organic EL display devices **1** and **1**A including: the light emitting layer **27** individually disposed in each sub pixel **3** and emitting light of a different color for each sub pixel **3**; the positive electrode **20** and the negative electrode **34** arranged facing each other, the light emitting layer **27** being disposed between the positive electrode **20** and the negative electrode **34**; and the common hole transport layer **25** common to the sub pixel **3**, the common hole transport layer **25** being disposed between the positive electrode **20** and the light emitting layer **27**, wherein the individual hole transport layer **26** is further individually disposed in each sub pixel **3**, between the common hole transport layer **25** and the light emitting layer **27** for each sub pixel **3**, and an energy level value (HTL-BL, HTL-GL, HTL-RL) of a Lowest Unoccupied Molecular Orbital (LUMO) of the individual hole transport layer **26** is smaller than an energy level value (HTL-L) of a Lowest Unoccupied Molecular Orbital (LUMO) of the common hole transport layer **25** and greater than an energy level value (EML-BL, EML-GL, EML-RL) of a Lowest Unoccupied Molecular Orbital (LUMO) of the light emitting layers **27**B, **27**G, and **27**R in the sub pixels **3**.

[0153] According to the configuration above, in each sub pixel, the individual hole transport layer is individually disposed, wherein the energy level value of the lowest unoccupied molecular orbital of the individual hole transport layer is smaller than the energy level value of the lowest unoccupied molecular orbital of the common hole transport layer, but larger than the energy level value of the lowest unoccupied molecular orbital of the light emitting layer in the sub pixel. Thus, a hole can be efficiently injected into the light emitting layer for each sub pixel. Therefore, the light emitting layer can efficiently emit light for each sub pixel.

[0154] In the organic EL display devices **1** and **1**A according to the second aspect of the disclosure, referring to the first aspect, in each sub pixel **3**, an energy level value (HIL-BH, HIL-GH, HIL-RH) of a Highest Occupied Molecular Orbital (HOMO) of the individual hole transport layer **26** is preferably larger than an energy level value (HTL-H) of a Highest Occupied Molecular Orbital (HOMO) of the common hole transport layer **25**, but preferably smaller than an energy level value (EML-BH, EML-GH, EML-RH) of a Highest Occupied Molecular Orbital (HOMO) of the light emitting layers **27**B, **27**G, and **27**R in the sub pixel **3**.

[0155] According to the configuration above, a hole can be efficiently injected into the light emitting layer for each sub pixel. Therefore, the light emitting layer can efficiently emit light for each sub pixel.

[0156] In the organic EL display devices **1**, **1**A, and **1**B according to the third aspect of the disclosure, a film thickness of individual hole transport layer **26** is different for each sub pixel **3**, providing optical adjustment between the positive electrode **20** and the light emitting layer **27**, or between the positive electrode **20** and the negative electrode **34**. According to the configuration above, a high definition image can be displayed.

[0157] In the organic EL display devices **1**, **1**A, and **1**B according to the fourth aspect of the disclosure, referring to the first to third aspects, the plurality of the sub pixels **3** of the pixels **2** may include a blue sub pixel **3**B, wherein the blue light emitting layer **27**B serving as light emitting layer **27** emitting blue light is disposed in the blue sub pixel.

[0158] In the organic EL display devices **1**, **1**A, and **1**B according to the fifth aspect of the disclosure, referring to the fourth aspect, a difference between the energy level value of the lowest unoccupied molecular orbital (LUMO) and the energy level value of the highest occupied molecular orbital (HOMO) is a HOMO-LUMO energy gap, and the HOMO-LUMO energy gap of the blue individual hole transport layer **26**B serving as the individual hole transport layer **26** disposed in the blue sub pixel **3**B may be largest among the plurality of sub pixels. According to the configuration above, a hole can be efficiently injected into the blue light emitting layer.

[0159] In the organic EL display devices **1**, **1**A, and **1**B according to the sixth aspect of the disclosure, referring to the fifth aspect above, a film thickness t**1** of the blue individual hole transport layer **26**B serving as the individual hole transport layer **26** disposed in the blue sub pixel **3**B may be thinnest among the plurality of sub pixels **3**. According to the configuration above, a hole can be efficiently injected into the blue light emitting layer.

[0160] In the organic EL display devices **1**, **1**A, and **1**B according to seventh aspect of the disclosure, referring to the first to sixth aspects above, the plurality of the sub pixels of the pixels may include the red sub pixel, wherein the red light emitting layer serving as the light emitting layer emitting red light is disposed in the red sub pixel.

[0161] In the organic EL display devices **1**, **1**A, and **1**B according to eighth aspect of the disclosure, referring to the seventh aspect above, the difference between the energy level value of the lowest unoccupied molecular orbital and the energy level value of the highest occupied molecular orbital is a HOMO-LUMO energy gap, and the HOMO-LUMO energy gap of the red individual hole transport layer **26**R serving as the individual hole transport layer **26** disposed in the red sub pixel **3**R may be smallest among the plurality of sub pixels **3**. According to the configuration above, a hole can be efficiently injected into the red light emitting layer.

[0162] In the organic EL display devices **1**, **1**A, and **1**B according to ninth aspect of the disclosure, referring to the seventh or eighth aspect above, a film thickness t**3** of the red individual hole transport layer **26**R serving as the individual hole transport layer **26** disposed in the red sub pixel **3**R may be thickest among the plurality of sub pixels **3**. According to the configuration above, a hole can be efficiently injected into the red light emitting layer.

[0163] In the organic EL display devices **1**, **1**A, and **1**B according to tenth aspect of the disclosure, referring to the seventh or eighth aspect, the plurality of the sub pixels **3** of the pixels **2** may include a green sub pixel **3**G, wherein the green light emitting layer **27**G serving as the light emitting layer **27** emitting green light is disposed in the green sub pixel.

[0164] In the organic EL display devices **1**, **1**A, and **1**B according to eleventh aspect of the disclosure, referring to the tenth aspect above, the difference between the energy level value of the lowest unoccupied molecular orbital and the energy level value of the highest occupied molecular orbital is a HOMO-LUMO energy gap, and the HOMO-LUMO energy gap of the green individual hole transport layer **26**G serving as the individual hole transport layer **26** disposed in the green sub pixel **3**G may be larger than the HOMO-LUMO energy gap of the red individual hole transport layer **26**R serving as the individual hole transport layer **26** disposed in the red sub pixel **3**R, among the plurality of sub pixels **3**. According to the configuration above, a hole can be efficiently injected into the red light emitting layer and the green light emitting layer.

[0165] In the organic EL display device **1** according to the twelfth aspect of the disclosure, referring to the tenth aspect above, a film thickness t**2** of the green individual hole transport layer **26**G serving as the individual hole transport layer **26** disposed in the green sub pixel **3**G may be thinner than the film thickness t**3** of the red individual hole transport layer **26**R serving as the individual hole transport layer **26** disposed in the red sub pixel **3**R, among the plurality of sub pixels **3**. According to the configuration above, a hole can be efficiently injected into the red light emitting layer and the green light emitting layer.

[0166] In the organic EL display devices **1**A and **1**B according to the thirteenth aspect of the disclosure, referring to the tenth aspect above, the difference between the energy level value of the lowest unoccupied molecular orbital and the energy level value of the highest occupied molecular orbital is a HOMO-LUMO energy gap, and the HOMO-LUMO energy gap of the green individual hole transport layer **26**G serving as the individual hole transport layer **26** disposed in the green sub pixel **3**G may be equal to the HOMO-LUMO energy gap of the red individual hole transport layer **26**R serving as the individual hole transport layer **26**R disposed in the red sub pixel **3**R, among the plurality of sub pixels **3**. According to the configuration above, the red individual hole transport layer and the green individual hole transport layer can include the same material. As a result, the production efficiency can be improved.

[0167] In the organic EL display devices **1**A and **1**B according to the fourteenth aspect of the disclosure, referring to the tenth or thirteenth aspect above, the film thickness t**2** of the green individual hole transport layer **26**G serving as the individual hole transport layer **26** disposed in the green sub pixel **3**G may be equal to the film thickness t**3** of the red individual hole transport layer **26**R serving as the individual hole transport layer **26** disposed in the red sub pixel **3**R, among the plurality of sub pixels **3**.

[0168] According to the configuration above, the red individual hole transport layer and the green individual hole transport layer can include the same material. As a result, the production efficiency can be improved.

[0169] In the organic EL display device **1**B according to fifteenth aspect of the disclosure, referring to the fourth to sixth aspects above, the individual hole transport layer **26** disposed in the sub pixels other than the blue sub pixel **3**B may be common across the plurality of the sub pixels other than the blue sub pixel, among the plurality of sub pixels **3**. According to the configuration above, the individual hole transport layer arranged in the other sub pixels described above can include the same material. As a result, the production efficiency can be improved.

[0170] The disclosure is not limited to each of the embodiments stated above, and various modifications may be implemented within a range not departing from the scope of the claims. Embodiments obtained by appropriately combining technical approaches stated in each of the different embodiments also fall within the scope of the technology of the disclosure. Moreover, novel technical features may be formed by combining the technical approaches stated in each of the embodiments.

REFERENCE SYMBOLS LIST

[0171] **1***a* Display region
[0172] **1**, **1**A, **1**B Organic EL display devices
[0173] **3** sub pixel
[0174] **3**B Blue sub pixel
[0175] **3**G Green sub pixel
[0176] **3**R Red sub pixel
[0177] **5** Organic EL element
[0178] **5**B Blue organic EL element
[0179] **5**G Green organic EL element
[0180] **5**R Red organic EL element
[0181] **10** TFT substrate
[0182] **11** Support body
[0183] **12** TFT
[0184] **13** Wiring line
[0185] **14** Passivation film
[0186] **15** Interlayer insulating film
[0187] **20** Positive electrode
[0188] **21** Reflective electrode
[0189] **22** Transparent electrode
[0190] **23** Edge cover
[0191] **24** Hole injecting layer
[0192] **25** Common hole transport layer
[0193] **25** Hole transport layer
[0194] **26** Individual hole transport layer
[0195] **26**B Blue individual hole transport layer (individual hole transport layer)
[0196] **26**G, **26**GA Green individual hole transport layer (individual hole transport layer)
[0197] **26**R, **26**RA Red individual hole transport layer (individual hole transport layer)
[0198] **26**RG Common individual hole transport layer (individual hole transport layer)
[0199] **27** Light emitting layer

[0200] **27**B Blue light emitting layer
[0201] **27**G Green light emitting layer
[0202] **27**R Red light emitting layer
[0203] **30** Organic EL layer
[0204] **31** Hole shielding layer
[0205] **32** Electron transport layer
[0206] **33** Electron injecting layer
[0207] **34** Negative electrode
[0208] **35** Circularly polarized light filter
[0209] **40** Sealing layer

1. (canceled)

2. An organic EL display device comprising pixels arranged on a display region in a matrix, the pixels comprising a plurality of sub pixels emitting light of different colors, the organic EL display device comprising:

- a light emitting layer individually disposed in each sub pixel and emitting light of a different color for each sub pixel;
- a positive electrode and a negative electrode arranged facing each other, the light emitting layer being disposed between the positive electrode and the negative electrode; and
- a common hole transport layer common to each sub pixel, the common hole transport layer being disposed between the positive electrode and the light emitting layer,
- wherein an individual hole transport layer is further individually disposed in each sub pixel, between the common hole transport layer and the light emitting layer for each sub pixel, and
- an energy level value of a lowest unoccupied molecular orbital of the individual hole transport layer is smaller than an energy level value of a lowest unoccupied molecular orbital of the common hole transport layer for each sub pixel and greater than an energy level value of a lowest unoccupied molecular orbital of the light emitting layer in the sub pixel, and
- in each sub pixel, an energy level value of a highest occupied molecular orbital of the individual hole transport layer is greater than an energy level value of a highest occupied molecular orbital of the common hole transport layer, and smaller than an energy level value of a highest occupied molecular orbital of the light emitting layer in the sub pixel.

3. The organic EL display device according to claim **2**, wherein a film thickness of the individual hole transport layer is different for each sub pixel, providing optical adjustment between the positive electrode and the light emitting layer or between the positive electrode and the negative electrode.

4. The organic EL display device according to claim **2**, wherein the plurality of sub pixels of the pixels comprise a blue sub pixel, a blue light emitting layer serving as the light emitting layer emitting blue light being disposed in the blue sub pixel.

5. The organic EL display device according to claim **4**, wherein a difference between an energy level value of a lowest unoccupied molecular orbital and an energy level value of a highest occupied molecular orbital is a HOMO-LUMO energy gap, and the HOMO-LUMO energy gap of a blue individual hole transport layer serving as the individual hole transport layer disposed in the blue sub pixel is largest among the plurality of sub pixels.

6. The organic EL display device according to claim **4**, wherein a film thickness of a blue individual hole transport layer serving as the individual hole transport layer disposed in the blue sub pixel is thinnest among the plurality of sub pixels.

7. The organic EL display device according to claim **2**, wherein the plurality of sub pixels of the pixels comprise a red sub pixel, a red light emitting layer serving as the light emitting layer emitting red light being disposed in the red sub pixel.

8. The organic EL display device according to claim **7**, wherein a difference between an energy level value of a lowest unoccupied molecular orbital and an energy level value of a highest occupied molecular orbital is a HOMO-LUMO energy gap, and the HOMO-LUMO energy gap of a red individual hole transport layer serving as the individual hole transport layer disposed in the red sub pixel is smallest among the plurality of sub pixels.

9. The organic EL display device according to claim **7**, wherein a film thickness of a red individual hole transport layer serving as the individual hole transport layer disposed in the red sub pixel is thickest among the plurality of sub pixels.

10. The organic EL display device according to claim **7**, wherein the plurality of sub pixels of the pixels comprise a green sub pixel, a green light emitting layer serving as the light emitting layer emitting green light being disposed in the green sub pixel.

11. The organic EL display device according to claim **10**, wherein a difference between an energy level value of a lowest unoccupied molecular orbital and an energy level value of a highest occupied molecular orbital is a HOMO-LUMO energy gap, and the HOMO-LUMO energy gap of a green individual hole transport layer serving as the individual hole transport layer disposed in the green sub pixel is greater than the HOMO-LUMO energy gap of a red individual hole transport layer serving as the individual hole transport layer disposed in the red sub pixel.

12. The organic EL display device according to claim **10**, wherein a film thickness of a green individual hole transport layer serving as the individual hole transport layer disposed in the green sub pixel is thinner than a film thickness of a red individual hole transport layer serving as the individual hole transport layer disposed in the red sub pixel among the plurality of sub pixels.

13. The organic EL display device according to claim **10**, wherein a difference between an energy level value of a lowest unoccupied molecular orbital and an energy level value of a highest occupied molecular orbital is a HOMO-LUMO energy gap, and the HOMO-LUMO energy gap of a green individual hole transport layer serving as the individual hole transport layer disposed in the green sub pixel is equal to the HOMO-LUMO energy gap of a red individual hole transport layer serving as the individual hole transport layer disposed in the red sub pixel.

14. The organic EL display device according to claim **10**, wherein a film thickness of a green individual hole transport layer serving as the individual hole transport layer disposed in the green sub pixel is equal to the film thickness of a red individual hole transport layer serving as the individual hole transport layer disposed in the red sub pixel among the plurality of sub pixels.

15. The organic EL display device according to claim **4**, wherein the individual hole transport layer disposed in a sub pixel other than the blue sub pixel is common across a plurality of the sub pixels other than the blue sub pixel among the plurality of sub pixels.

16. An organic EL display device comprising pixels arranged on a display region in a matrix, the pixels comprising a plurality of sub pixels emitting light of different colors, the organic EL display device comprising:

a light emitting layer individually disposed in each sub pixel and emitting light of a different color for each sub pixel;

a positive electrode and a negative electrode arranged facing each other, the light emitting layer being disposed between the positive electrode and the negative electrode; and

a common hole transport layer common to each sub pixel, the common hole transport layer being disposed between the positive electrode and the light emitting layer,

wherein an individual hole transport layer is further individually disposed in each sub pixel, between the common hole transport layer and the light emitting layer for each sub pixel, and

an energy level value of a lowest unoccupied molecular orbital of the individual hole transport layer is smaller than an energy level value of a lowest unoccupied molecular orbital of the common hole transport layer for each sub pixel and greater than an energy level value of a lowest unoccupied molecular orbital of the light emitting layer in the sub pixel, and the plurality of sub pixels of the pixels comprise a blue sub pixel, a blue light emitting layer serving as the light emitting layer emitting blue light being disposed in the blue sub pixel, and

a difference between an energy level value of a lowest unoccupied molecular orbital and an energy level value of a highest occupied molecular orbital is a HOMO-LUMO energy gap, and the HOMO-LUMO energy gap of a blue individual hole transport layer serving as the individual hole transport layer disposed in the blue sub pixel is largest among the plurality of sub pixels.

17. The organic EL display device according to claim **16**, wherein a film thickness of the individual hole transport layer is different for each sub pixel, providing optical adjustment between the positive electrode and the light emitting layer or between the positive electrode and the negative electrode.

18. The organic EL display device according to claim **16**, wherein a film thickness of a blue individual hole transport layer serving as the individual hole transport layer disposed in the blue sub pixel is thinnest among the plurality of sub pixels.

19. The organic EL display device according to claim **16**, wherein the plurality of sub pixels of the pixels comprise a red sub pixel, a red light emitting layer serving as the light emitting layer emitting red light being disposed in the red sub pixel.

20. An organic EL display device comprising pixels arranged on a display region in a matrix, the pixels comprising a plurality of sub pixels emitting light of different colors, the organic EL display device comprising:

a light emitting layer individually disposed in each sub pixel and emitting light of a different color for each sub pixel;

a positive electrode and a negative electrode arranged facing each other, the light emitting layer being disposed between the positive electrode and the negative electrode; and

a common hole transport layer common to each sub pixel, the common hole transport layer being disposed between the positive electrode and the light emitting layer,

wherein an individual hole transport layer is further individually disposed in each sub pixel, between the common hole transport layer and the light emitting layer for each sub pixel, and

an energy level value of a lowest unoccupied molecular orbital of the individual hole transport layer is smaller than an energy level value of a lowest unoccupied molecular orbital of the common hole transport layer for each sub pixel and greater than an energy level value of a lowest unoccupied molecular orbital of the light emitting layer in the sub pixel, and the plurality of sub pixels of the pixels comprise a blue sub pixel, a blue light emitting layer serving as the light emitting layer emitting blue light being disposed in the blue sub pixel, and

the individual hole transport layer disposed in a sub pixel other than the blue sub pixel is common across a plurality of the sub pixels other than the blue sub pixel among the plurality of sub pixels.

21. The organic EL display device according to claim **20**, wherein a difference between an energy level value of a lowest unoccupied molecular orbital and an energy level value of a highest occupied molecular orbital is a HOMO-LUMO energy gap, and the HOMO-LUMO energy gap of a blue individual hole transport layer serving as the individual hole transport layer disposed in the blue sub pixel is largest among the plurality of sub pixels.

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[标]申请(专利权)人(译)	夏普株式会社		
申请(专利权)人(译)	夏普株式会社		
当前申请(专利权)人(译)	夏普株式会社		
[标]发明人	JO TOMOAKI KAWATO SHINICHI NIBOSHI MANABU TSUKAMOTO YUTO IMADA HIROSHI UMEDA TOKIYOSHI ZHANG BAI		
发明人	JO, TOMOAKI KAWATO, SHINICHI NIBOSHI, MANABU TSUKAMOTO, YUTO IMADA, HIROSHI UMEDA, TOKIYOSHI ZHANG, BAI		
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摘要(译)

在每个子像素中的公共空穴传输层和发光层之间分别设置有单个空穴传输层，并且该单个空穴传输层的最低未占据分子轨道的能级值小于该空穴能级的能级值。空穴传输层的最低未占据分子轨道的最低能级，但大于子像素中发光层的最低未占据分子轨道的能级值。因此，可以将空穴有效地注入到发光层中。