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(54) Organic electroluminescent element, display and illuminator

Organisches elektrolumineszentes Element, Bildschirm und Beleuchtungseinheit

Élément électroluminescente organique, écran, illuminateur

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Description

[0001] The present invention relates to an organic electroluminescent element, a display and an illuminator.

[0002] An electroluminescent element (hereinafter also referred to as an EL element) is superior in visibility since it emits light itself. The element including the driving circuit can be made light because the element can be driven by a low voltage of several volts or several tens of volts. Therefore an organic EL element is used for thin type displays, illuminators and backlights.

[0003] It is also a feature of the organic EL element that it has abundant color variation. Moreover, it is also a feature that various colors can be obtained by mixing plural colors of the emitted light.

[0004] Among the colors of the emitted light, the need for white color light is especially great (eg in a backlight). Moreover white light can be separated into blue, green and red pixels.

[0005] For emitting white light, the following two methods can be applied.

1. dope plural light emitting compounds into a light emission layer
2. combine plural colors of light emitted from plural light emission layers

[0006] For instance, when method 1 is applied using a vacuum vapor deposition method for attaining white color by mixing blue (B), green (G) and red (R), a vapor deposition of four elements of B, G, R and a host compound should be carried out, which is difficult to control.

[0007] Another method can be applied in which a solution formed by dissolving or dispersing the B, G, R and host compounds is coated. However, it is a problem that the coated type EL element is inferior in durability to the vapor deposited type element.

[0008] On the other hand, method 2 combines plural light emission layers. Such a method is easier than vapor deposition.

[0009] There is known a white light emission EL element in which a blue light emitting layer as a short wavelength light emission layer and a red light emission layer as a long wavelength light emission layer are laminated so as to emit white light by mixing light emitted from the two light emission layers (for example see JP-A-7/142169).

[0010] However, in the element having the two laminated light emission layers different from each other in the color of the emitting light (different in the peak wavelength of emitted light), the light emitting center is moved by variation in the layer quality or transportability of the positive hole and the electron accompanied with the variation in the driving time or variation in the light emitting time and the applied voltage so that the chromaticity tends to be varied.

[0011] Such a problem is realised when white light is obtained by mixing light emitted from the two light emission layers since white light is sensitive to variation in chromaticity.

[0012] US2002/027416 discloses an electroluminescence device which includes NPB as a host material in adjacent layers. WO-A-02/091814 discloses carbazole host compounds.

[0013] As a method for inhibiting the chromaticity variation caused by the variation in the driving time whilst keeping the voltage as low as possible, there is known an EL element emitting mixed light composed of lights each different in the peak wavelength emitted from each of plural light emission layers and in which three or more light emission layers each emitting light different in the peak wavelength are alternatively laminated (for example see JP-A-2003/187977).

[0014] Moreover, there is known a method for designing the laminated structure having two or more layers utilizing the thickness of the light emission layer and the ratio of an organic host material to a fluorescent material as parameters of the light emission efficiency (see for example JP-A-2004/63349).

[0015] The above means are effective for inhibiting chromaticity deviation by alternately laminating the layers even when the balance of injection of the carriers is lost to some degree. It is found, however, that the light emitting efficiency is low, energy transfer between the layers is caused and deviation in the whiteness is observed so that such elements are insufficient in white light emission.

[0016] A known example of attaining white light by the combination of plural light emission layers is an element having two light emitting layers each different in the emitting light color and an intermediate layer arranged between the light emission layers (see for example Applied Physics Letters, Vol. 83, 2459 (2003) and Advanced Materials, Vol. 14, No. 2, 147 (2002)).

[0017] The above technique, however, has the following problems:

1. Color of emitted light is deviated depending on the applied voltage (electric current).
2. The efficiency is not attained to the theoretical limit.
3. The process is made complex by the formation of the intermediate layer.

[0018] The above problems remain to be solved.

[0019] An object of the present invention is to provide an organic electroluminescent displaying high external quantum efficiency or high light emission efficiency and inhibited in chromaticity deviation, a display and an illuminator.

[0020] Thus viewed from one aspect the present invention provides an organic electroluminescent element comprising an anode; a cathode; at least two light emission layers provided between the anode and the cathode; and at least one intermediate layer provided between the two light emission layers, wherein the two light emission layers each comprise the same host compound A; one of the two light emission layers comprises light emission dopant A and the other light emission layer comprises light emission dopant B which is different from light emission dopant A; and the intermediate layer comprises host compound A, wherein host compound A is a carbazole derivative.

Fig. 1 shows a schematic drawing of an example of display constituted by organic EL elements.
Fig. 2 shows a schematic drawing of display A.
Fig. 3 shows an equivalent circuit drawing of a driving circuit constituting a pixel.
Fig. 4 shows a schematic drawing of a display of passive matrix system.
Fig. 5 shows a schematic drawing of the sealing structure of Organic EL Element 1-1.
Fig. 6 shows a schematic drawing of an illuminator having EL elements.
Fig. 7 shows a schematic drawing of an example of vapor deposition to be applied for forming the light emission layer of organic EL element.
Fig. 8 shows a schematic drawing of an example of vapor deposition to be applied for forming the light emission layer of organic EL element.
Fig. 9 shows an example of layer constitution of the organic EL element.
Fig. 10 shows layer structures of the organic EL element of the present invention.
Fig. 11 shows layer structures of the organic EL element of the present invention.
Fig. 12 shows layer structures of the organic EL element of the present invention.
Fig. 13 shows layer structures of the organic EL element of the present invention.

[0021] The object of the present invention is attained by the first aspect of the invention.

[0022] Preferably at least one of dopants A and B is a phosphorescent compound.

[0023] Preferably each of dopants A and B is a phosphorescent compound.

[0024] Preferably a thickness of the intermediate layer is larger than a Förster distance between light emission dopant A and light emission dopant B.

[0025] Preferably the organic electroluminescent element comprises at least one type of light emission layers comprising two or more layers of the same type showing the same light emission peak.

[0026] Preferably the organic electroluminescent element comprises at least two types of light emission layers, each type comprising two or more layers of the same type showing the same light emission peak.

[0027] Preferably the organic electroluminescent element comprises at least two types of light emission layers A and B, wherein light emission layer A or light emission layer B comprises two or more layers; and light emission layer A, light emission layer B and , the intermediate layer are laminated alternately.

[0028] Preferably the organic electroluminescent element comprises at least three types of light emission layers A, B and C, wherein at least one of light emission layers A, B and C comprises two or more layers; and the light emission layers A, B and C are laminated periodically.

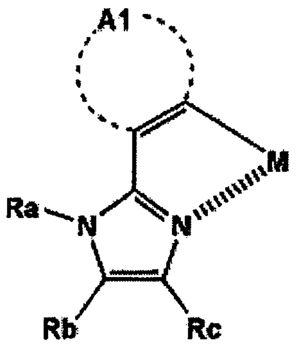
[0029] Preferably the organic electroluminescent element comprises a hole blocking layer provided between a light emission layer and the cathode; and at least one of the hole blocking layer is provided adjacent to the light emission layer.

[0030] Preferably the organic electroluminescent element comprises an electron blocking layer provided between the light emission layer and the anode; and at least one of the electron blocking layer is provided adjacent to the light emission layer.

[0031] Preferably the organic electroluminescent element emits white light.

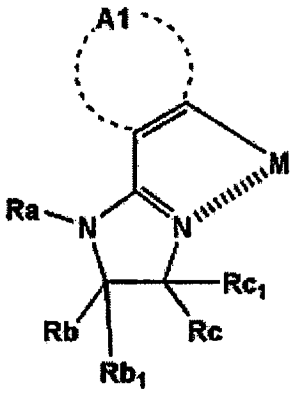
[0032] Preferably the light emission layer comprises a light emission dopant having at least one of substructures represented by Formulae (A) to (C)

Formula (A)



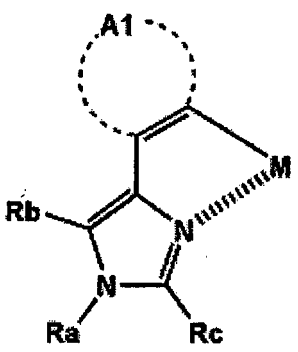
wherein, Ra is a hydrogen atom, an aliphatic group, an aromatic group or a heterocyclic group, Rb and Rc each are a hydrogen atom or a substituent, A1 is a residue necessary to form an aromatic ring or an aromatic heterocyclic ring and M is Ir or Pt;

Formula (B)



wherein Ra is a hydrogen atom, an aliphatic group, an aromatic group or a heterocyclic group, Rb, Rc, Rb_1 and Rc_1 each are a hydrogen atom or a substituent, A1 is a residue necessary to form an aromatic ring or an aromatic heterocyclic ring and M is Ir or Pt;

Formula (C)



wherein Ra is a hydrogen tom, an aliphatic group, an aromatic group or a heterocyclic group, Rb and Rc each are a hydrogen atom or a substituent, A1 is a residue necessary to form an aromatic ring or an aromatic heterocyclic ring and

M is Ir or Pt.

[0033] Viewed from a further aspect the present invention provides a display comprising an organic electroluminescent element as hereinbefore defined.

[0034] Viewed from a yet further aspect the present invention provides a illuminator comprising an organic electroluminescent element as hereinbefore defined.

[0035] In the present invention, an organic EL element having high external quantum efficiency or high light emission efficiency and small chromaticity deviation may be provided by any of the aforementioned embodiments.

[0036] The inventors investigated deviation of chromaticity of the emitted white light when plural kinds of light emission layers are combined and an intermediate layer is provided between the light emission layers. As a result of the investigation, it was noted that the confinement of the exciton is insufficient and injection balance of positive hole and electron through the intermediate layer is not constant related to the deviation of chromaticity of the emitted light.

[0037] In the present invention, it has been clarified that, by using the same compound as the host material for forming the intermediate layer and the light emission layer, the injection barrier between the layers is lowered whereby the injection balance of the positive hole is made constant even when the driving voltage or current is changed. This results in a notable reduction in the chromaticity deviation.

[0038] Moreover from the viewpoint of the production of the organic EL element, the production process is considerably simplified compared with usual processes by using the common material for the host compound and the intermediate layer.

[0039] It has also been successful to effectively confine the triplet exciton of the light emission layer by using the material in the intermediate layer which has triplet excitation energy higher than that of the phosphorescent compound in the light emission layer. Furthermore, by making the thickness of the intermediate layer greater than the Foester distance, the chromaticity deviation was reduced since the energy transfer of the exciton was suppressed and an element exhibiting a high efficiency was obtained. The laminating order of the light emission layers may be either regular or random and the intermediate layers are not necessary to be wholly provided and may be provided only at the necessary position.

<<Light emission layer>>

[0040] The light emission layer relating to the present invention is described below.

[0041] An example of the layer constitution of the organic EL element according to the present invention is described below with reference to Fig. 9 but the present invention is not limited thereto (the detailed layer constitution will be described later).

[0042] In the structure of the embodiment shown in Fig. 9, the element has the light emission layer provided between the cathode and the anode and the light emission layer is put between an electron blocking layer and a hole blocking layer.

[0043] Though the electron blocking layer or the hole blocking layer is not always necessary, these layers are preferably provided since the carriers of electrons-positive holes can be confined in the light emission layer and the exciton generated by recombination of the electron and the positive hole can be also confined in the light emission layer according to the embodiment of Fig. 9 (the electron blocking layer and the hole blocking layer will be described later).

[0044] Known materials can be used for forming the electron blocking layer and the hole blocking layer.

[0045] It is preferable that the material for forming the electron blocking layer has electron affinity lower than that of the material for forming the light emission layer for confining the electron so as not to leak the electron from the light emission layer.

[0046] It is preferable that the material for forming the hole blocking layer has an ionization potential higher than that of the material for forming the light emission layer for confining the electron so as not to leak the electron from the light emission layer.

[0047] For confining the triplet exciton generated by the recombination of the electron and the positive hole, the materials forming the electron blocking layer or the hole blocking layer are higher than the phosphorescent compound of the light emission layer in the triplet exciton energy.

[0048] A hole transport layer and an electron transport layer are preferably provided so as to sandwich them. Known materials can be used for forming the hole transport layer and the electron transport layer. It is preferable that these materials each have high electroconductivity for lowering the diving voltage.

[0049] Examples of the constitution of the light emission layer are described with reference to Figs. 10 to 18.

[0050] Only the light emitting portions are shown for light emission layers 1-1 to 3-6.

[0051] In the present invention, the light emission layer has at least two layers. Preferred is an embodiment in which at least one type of light emission layer comprising two or more layers of the same type showing the same light emission peak (as described in claim 5) or an embodiment in which at least two types of light emission layers, each type comprising two or more layers of the same type showing the same light emission peak (as described in claim 6).

[0052] In the present invention, the feature "the two layers exhibit the same light emission peak" is defined as follows.

When the two peaks of light obtained from the two light emission layers are analyzed via a PL measurement, the difference between the two emission peak wavelengths is less than 10nm.

[0053] In the PL measurement, the emission peak wavelength can be determined by preparing a vapor deposited layer having the same composition of the light emission dopant and the host compound to be used in the light emission layer on a quartz substrate or by preparing a thin layer of the composition such as a polymer by a spin coating method or dipping method when the layer is prepared by a wet process, and by measuring the emitted light of the above prepared vapor deposited layer or the thin layer by a fluorescence spectral photometer.

[0054] Though the color of emitted light from the organic EL element is not specifically limited, white light is preferred.

[0055] Where the element has two kinds of light emission layer each different in the light emitting peak, a combination of light emission layers each emitting blue light and yellow light or bluish green light and red light is preferred for obtaining white light. When three kinds of light emission layers having different light emission peaks are used, a combination of ones each emitting blue, green or red light are preferred for obtaining white light.

[0056] The elements can be used for various light sources such as an illuminator and a backlight.

[0057] When four kinds of light emission layer different in the light emission peak from each other are used, white light can be obtained by combining blue, bluish green, yellow and red. Other than the above, a layer can be added for compensating the white color obtained by the combination of blue, green and red.

[0058] In the present invention, the emitted light is not limited to white light.

[0059] When a single color such as blue, green or red is emitted, the fine control of the color can be realised by emitting light by plural light emission layers different in the light emitting peak from each other.

[0060] In the light emission layer relating to the present invention, the plural light emission layers may be laminated cyclically or randomly.

[0061] The layers are preferably arranged so that the chromaticity deviation caused by the variation of the applied voltage (current) is minimised.

[0062] The cyclical arrangements such as Light Emission Layers 1-3 to 1-6, 2-2, 2-5, 2-6, 2-7, 2-8, 2-9, 3-3, 3-4, 3-5 and 3-6 are preferable.

[0063] By such an arrangement, the deviation of the emitted light color can be reduced even when the light emitting position is shifted in the thickness direction by the variation of the applied voltage (current).

[0064] On the other hand, when plural color lights each generated from plural light emission layers are combined, the plural layers are laminated alternatively, cyclically or randomly for inhibiting the chromaticity deviation to minimum. In such a case, the number of faces contacting with the adjacent layer is increased and the chance of energy transfer between the layers is increased so that the same problem as that in the white light emission element constituted by a single light emission layer is caused.

[0065] The energy transfer in the organic EL element is principally Förster type. However, the energy transfer distance is large in the Förster energy transfer.

[0066] For the Förster type energy transfer, it is an important factor that the integral strength of overlapping of the emitted light spectrum of the donor molecule and the absorption spectrum of the acceptor molecule is basically large.

[0067] In the case of the fluorescent compound, the singlet excitation energy transfer distance is increased when the spectra are overlapped since the fluorescent quantum yield and mole light absorption coefficient are raised.

[0068] In the phosphorescent compound, the energy transfer at the triplet excitation energy transfer occurs (the same as in the fluorescent compounds) when T←G absorption is observed. Förster energy transfer is referred to by Joseph R. Lakowicz, "Principles of Fluorescence Spectroscopy", p. 368, Kluwer Academic Plenum Publisher. However, the mole light absorption coefficient of the T←G absorption is very small compared with that of the fluorescent compound. Therefore, the Förster type energy transfer distance in the phosphorescent compound is extremely small compared with that of the fluorescent compound.

[0069] In the present invention, the Förster energy transfer between the light emission layers can be suppressed by providing an intermediate layer having triplet excitation energy higher than that of the light emission layer whereby an element having high efficiency and showing limited chromaticity deviation can be obtained.

[0070] The energy transfer between the light emission dopants in the adjacent layers is progressed by Förster type. Therefore, the lamination order of the light emission layers can be decided so that the Förster distance becomes small. The Förster distance is a distance at which the ratio of the probability of transfer and that of internal conversion of energy is 1:1 and the energy transfer is principally caused in a distance smaller than the Förster distance and the energy transfer occurs with difficulty in a distance larger than that (Joseph R. Lakowicz, "Principles of Fluorescence Spectroscopy", p. 368, Kluwer Academic Plenum Publisher).

[0071] The Förster distance of some samples of phosphorescent compound was measured. Results of the measurement are listed below. The structures of the phosphorescent compounds are shown later in the description regarding the light emission dopant.

Phosphorescent compound (Also called light emission dopant)	Förster type energy transfer distance
Ir-12 → Ir-9	2.3 nm
Ir-12 → Ir-1	1.8 nm
Ir-13 → Ir-1	2.4 nm
Ir-1 → Ir-9	1.8 nm

[0072] The measurement was carried out by the method described in Joseph R. Lakowicz, "Principles of Fluorescence Spectroscopy", p. 368, Kluwer Academic Plenum Publisher.

[0073] The distance in other fluorescent compounds (also referred to as light emission dopant) described in the later examples are not more than 3 nm (similar to the above compounds).

[0074] Though the Förster type energy transfer distance of the phosphorescent compound is smaller than that of the fluorescent compound, it is confirmed that the transfer occurs in a short distance. For instance, the Förster distance of the transfer from Ir-12 (Fir (also referred to as pic)) to Ir-9 (btp_2Ir (also referred to as (acac)) is 2.3 nm.

[0075] Although the energy transfer distance is small, there is the probability that chromaticity deviation and efficiency lowering caused by occurrence of the energy transfer becomes not preferable problems in the white light emission element.

[0076] In the present invention, the organic electroluminescent element inhibited in the chromaticity deviation and having high efficiency can be obtained by inhibiting the Förster type energy transfer by the intermediate layer provided between two light emission layers each containing a different light emission dopant (phosphorescent compound) respectively.

[0077] It is understood from the above that energy transfer can be effectively inhibited and an element having high efficiency and lowered in chromaticity deviation can be obtained by setting the thickness of the intermediate layer (detail of the intermediate layer is described later) at not less than 2.5 to 5 nm.

[0078] Of course, the thickness of the intermediate layer can be made thinner when a combination of phosphorescent compounds each having small energy transfer distance is applied.

[0079] Moreover, the electric current-voltage characteristic can be varied by selection of the host compound.

[0080] The whole thickness of the light emission layer is preferably 5 to 100 nm, more preferably 7 to 50 nm and most preferably 10 to 40 nm.

[0081] The thickness of each of the plural light emission layers constituting the light emission layer is preferably 1 to 20 nm and more preferably 2 to 10 nm.

[0082] The thickness of the layer can be decided according to the element driving voltage, the chromaticity deviation responding to the voltage (current), the energy transfer and the difficulty of production.

[0083] In the present invention, it is necessary to contain the phosphorescent compound in at least one layer constituting the light emission layer and preferably in the entire light emission layers.

(Light emission host and light emission dopant)

[0084] The mixing ratio of the host compound which is the main component of the light emission layer to the light emission dopant is preferably 0.1% to less than 30% by weight.

[0085] The light emission dopant may be a mixture of a plurality of compounds. The partner of mixing may be another metal complex or a fluorescent dopant.

[0086] The dopants (phosphorescent dopants and fluorescent dopants) capable of being used together with the metal complex to be used as the light emission dopant are described below.

[0087] The light emission dopants can be roughly classified into a fluorescent dopant emitting fluorescence and a phosphorescent dopant emitting phosphorescence.

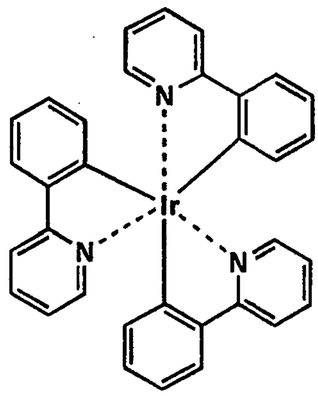
[0088] Typical examples of the former (fluorescent dopant) include a coumalin type dye, a pyrane type dye, a cyanine type dye, a chroconium type dye, a squalium type dye, an oxobenzanthracene type dye, a fluorescein type dye, a rhodamine type dye, a pyrylium type dye, a perylene type dye, a stilbene type dye, a polythiophene type dye and a rare-earth metal complex type fluorescent compound.

[0089] Typical examples of the latter (phosphorescent dopant) are preferably a complex compound containing a metal included in Groups 8, 9 or 10 of periodic table, and more preferably an iridium compound and an osmium compound. Among them, the iridium compounds are most preferred.

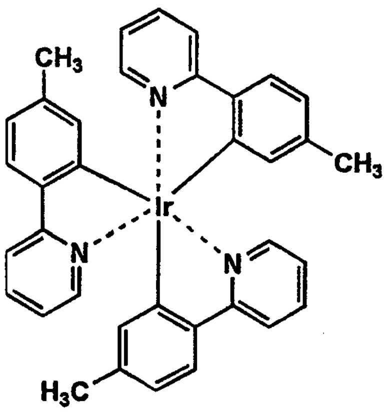
[0090] Specific examples are compounds described in WO 00/70655, JP-A Nos. 2002-280178, 2001-181616, 2002-280179, 2001-181617, 2002-280180, 2001-247859, 2002-299060, 2001-313178, 2002-302671, 2001-345183 and 2002-324679, WO 02/15645, JP-A Nos. 2002-332291, 2002-50484, 2002-332292 and 2002-83684, Published Japanese Translation of PCT International Publication No. 2002-540572, JP-A Nos. 2002-117978, 2002-238588, 2002-170684 and 2002-352960, WO 01/93642, JP-A Nos. 2002-50483, 2002-100476, 2002-173674, 2002-359082, 2002-175884, 2002-363552, 2002-184582 and 2003-7469, Published Japanese Translation of PCT International Publication No. 2002-525808, JP-A No. 2003-7471, Tokuhyou 2002-525833, and JP-A Nos. 2003-31366, 2002-226495, 2002-234894, 2002-235076, 2002-241751, 2001-319779, 2001-318780, 2002-62824, 2002-100474, 2002-203679, 2002-343572 and 2002-203678

[0091] A number of these examples are shown below.

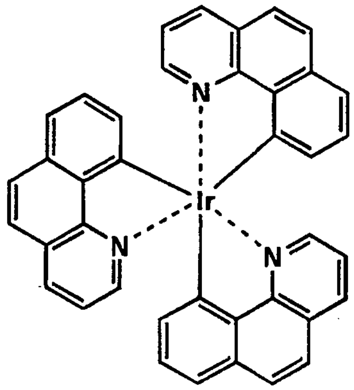
Ir−1



Ir−2



Ir−3



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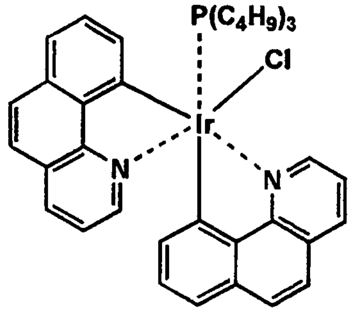
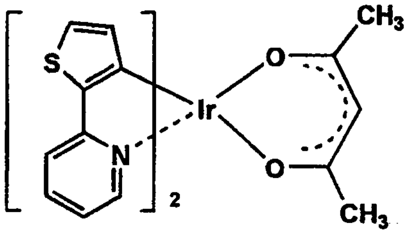


Ir−5



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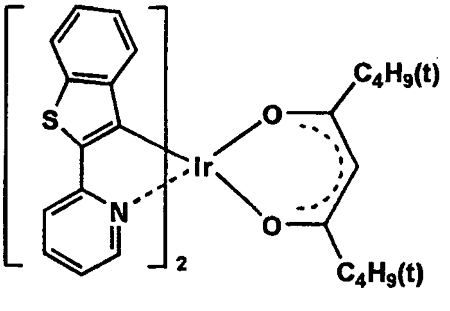

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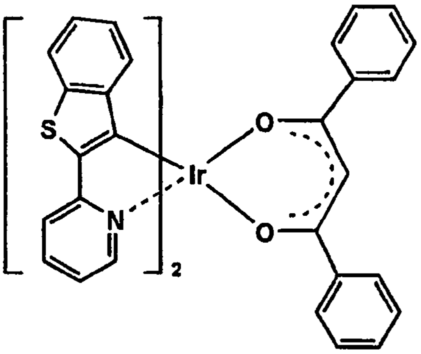

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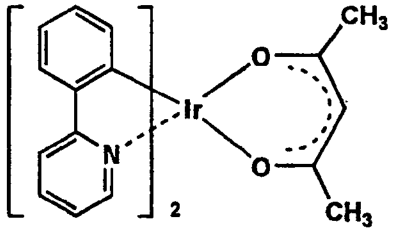
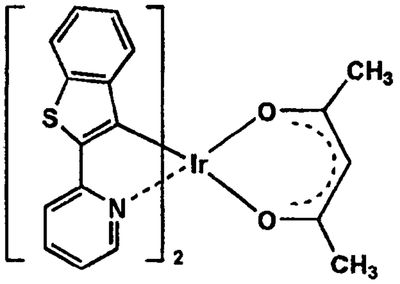
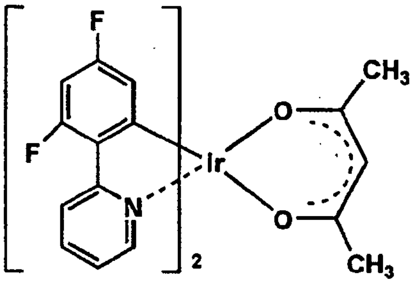


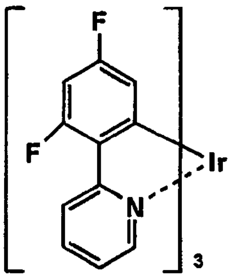
Ir−9



Ir−10



Ir−11



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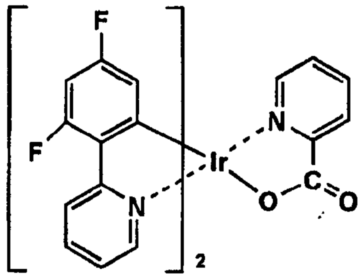
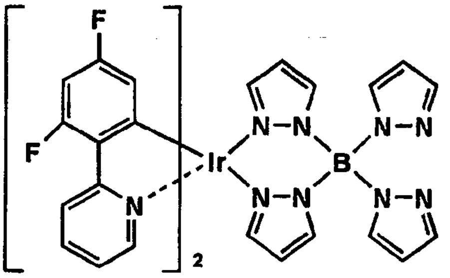
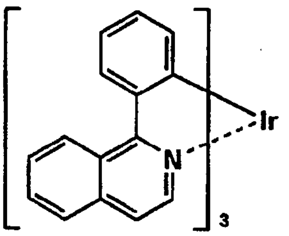


Ir−13



Ir−14



[0092] The light emission dopant compounds relating to the present invention having a partial structure represented by Formulae (A) to (C) described below.

[0093] It is preferable to use a compound having a partial structure represented by Formulae (A) to (C) as the light emission dopant in at least one of the light emission layers of the present invention. Particularly it is preferred to use those as the light emission dopant in the blue light emission layer.

[0094] In Formulae (A) to (C), A1 is a residue necessary to form an aromatic ring or an aromatic heterocyclic ring and examples of the aromatic ring include a benzene ring, a biphenyl ring, a naphthalene ring, an azulene ring, an anthracene ring, a phenanthrene ring, a pyrene ring, a chrysene ring, a naphthacene ring, a triphenylene ring, an o-terphenyl ring, a m-terphenyl ring, a p-terphenyl ring, an acenaphthene ring, a coronene ring, a fluorene ring, a fluoranthrene ring, a naphthacene ring, a pentacene ring, a perylene ring, a pentaphene ring, a picene ring, a pyrene ring, a pyranthrene ring and an anthranthrene ring, and examples of the aromatic heterocyclic ring include a furan ring, a thiophene ring, a pyridine ring, a pyridazine ring, a pyrimidine ring, pyrazine ring, triazine ring, a benzimidazole ring, an oxadiazole ring, a triazole ring, an imidazole ring, a pyrazole ring, a thiazole ring, an indole ring, a benzimidazole ring, a benzothiazole ring, a benzoxazole ring, a quinoquisaline ring, a quinazoline ring, a phthalazine ring, a carbazole ring, a carboline ring and a diazacarbazole ring (a ring in which one of the carbon atoms constituting a carboline ring is further substituted by a nitrogen atom).

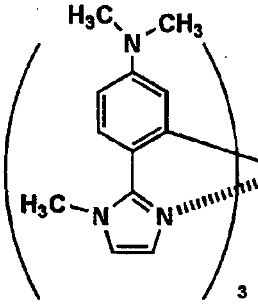
[0095] In Formulae (A) to (C), Ra is a hydrogen atom, an aliphatic group, an aromatic group or a heterocyclic group, Rb, Rc, Rb_1 and Rc_1 are each a hydrogen atom or a substituent, and Ra is the same as the above Ra_1 and the substituent represented by Rb, Rc, Rb_1 or Rc_1 are the same as the substituents represented by the above R_1 to Rg, RA or RB.

[0096] The structure represented by Formulae (A) to (C) is a partial structure and ligands corresponding to the valent number of the central metal are necessary for completing the structure of the light emission dopant. Specific examples of the ligand include a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom and an iodine atom, an aryl group such as a phenyl group, a p-chlorophenyl group, a mesityl group, a tolyl group, a xylyl group, a biphenyl group, a naphthyl group, an anthryl group and a phenanthryl group, an alkyl group such as a methyl group, an ethyl group, an isopropyl group, a hydroxylethyl group, a methoxymethyl group, a trifluoromethyl group and a t-butyl group, an alkyloxy group, an aryloxy group, an alkylthio group, an arylthio group, a heterocyclic group such as a furyl group, a thienyl group, a pyridyl group, a pyridazinyl group, a pyrimidinyl group, a pyrazinyl group, a triazinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, a quinazolinyl group, a carbazolyl group, a carbolinyl group and a phthalazinyl group and a partial structure represented by Formulae (A) to (C) without metal moiety.

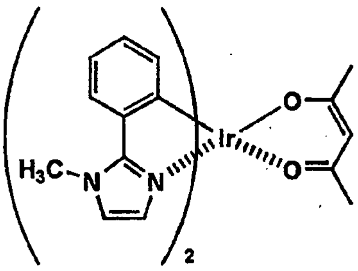
[0097] In Formulae (A) to (C), M is Ir or Pt and Ir is particularly preferable. A tris compound completed by three partial structures of Formulae (A) to (C) is preferred.

[0098] Examples of the dopant compound relating to the present invention having the partial structures represented by Formulae (A) to (C) are listed below but the compound is not limited to them.

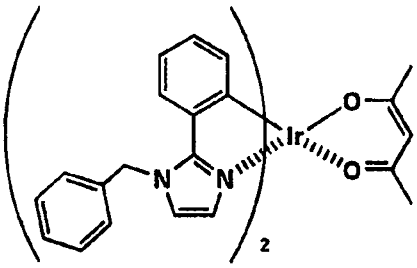
D−16



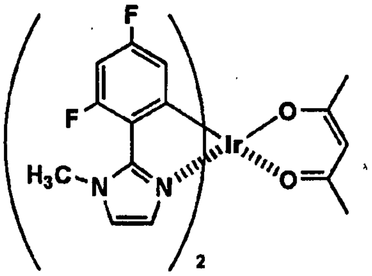
D−17



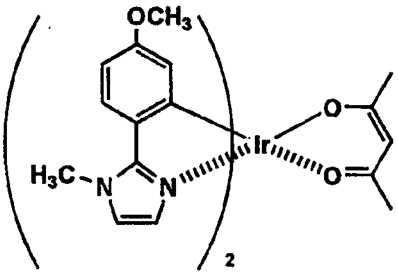
D−18



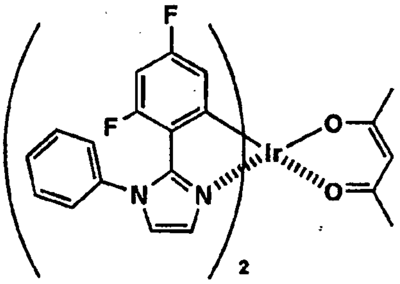
D−19



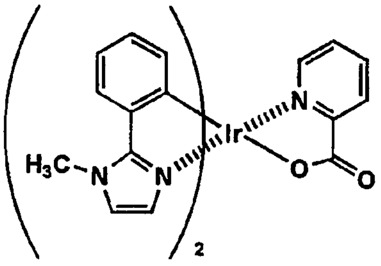
D−20



D−21



D−22



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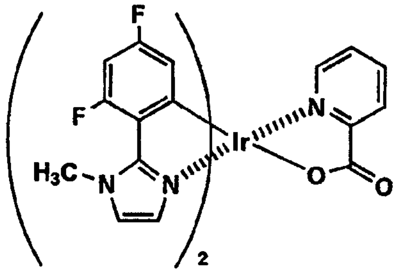
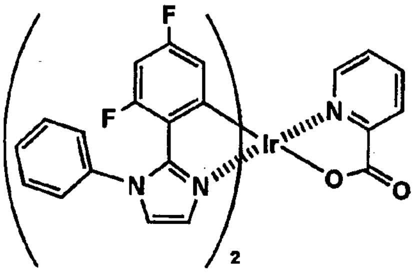
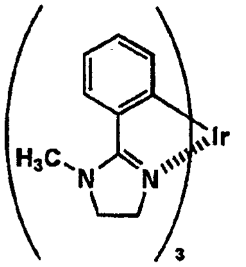


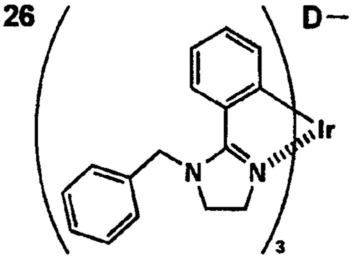
D−24



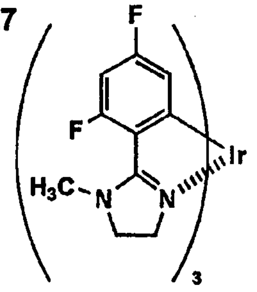
D−25



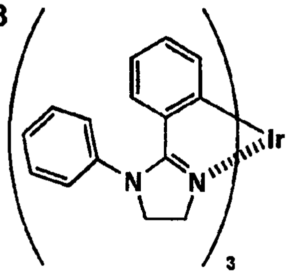
D−26



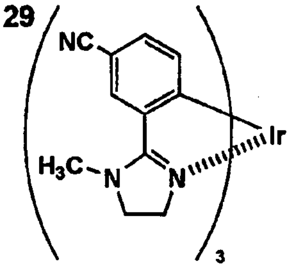
D−27



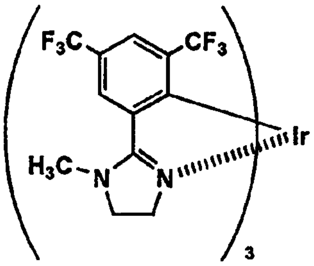
D−28



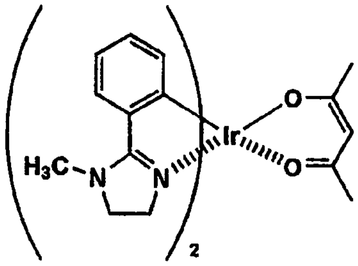
D−29



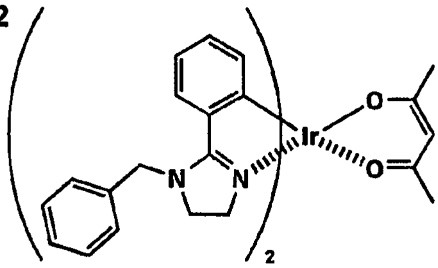
D−30



D−31



D−32



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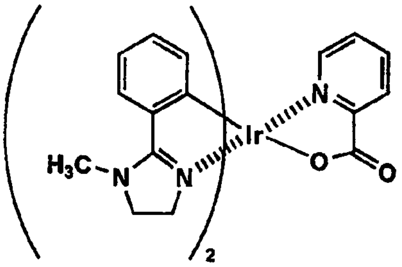

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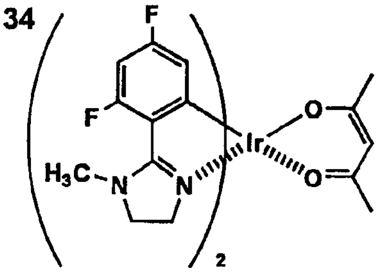

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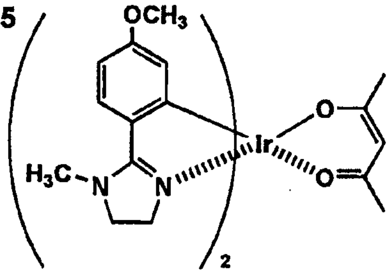
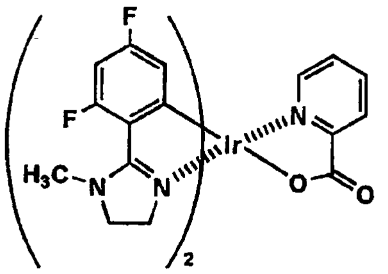


D−36



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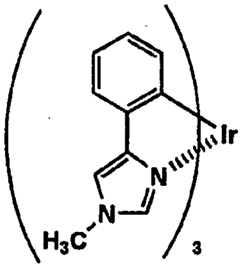

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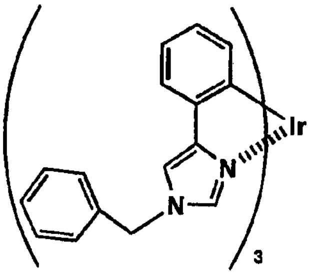

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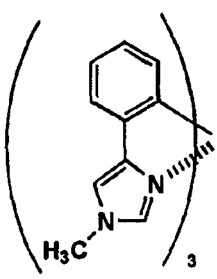

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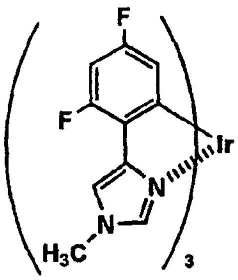

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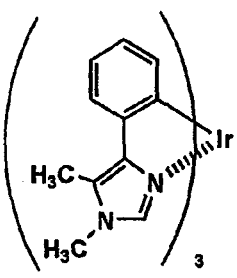

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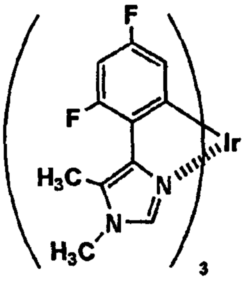

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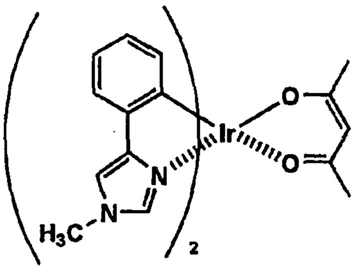

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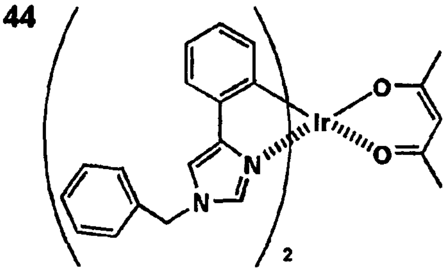

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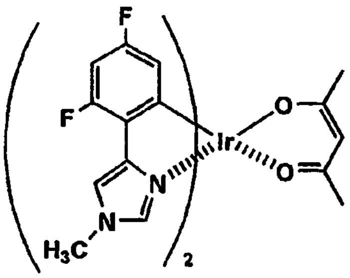
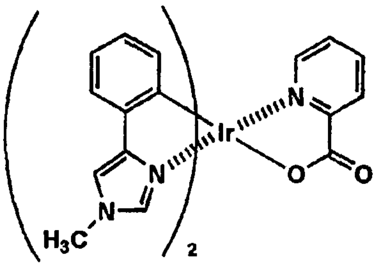
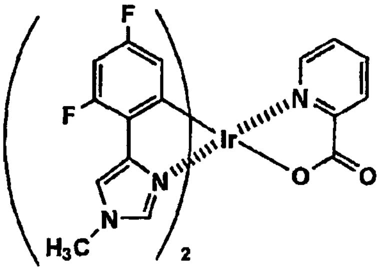


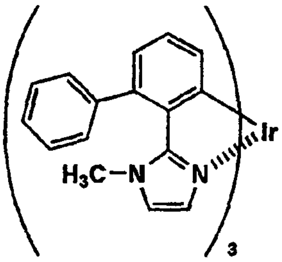
D−46



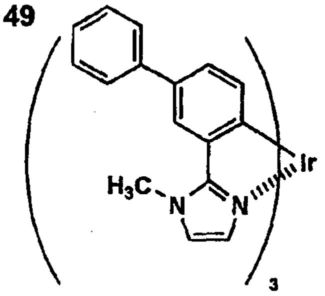
D-47



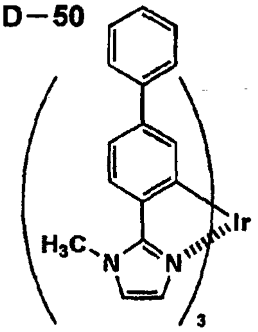
D-48



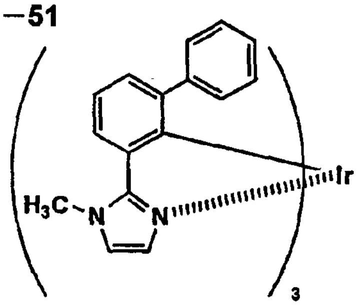
D-49



D-50



D-51



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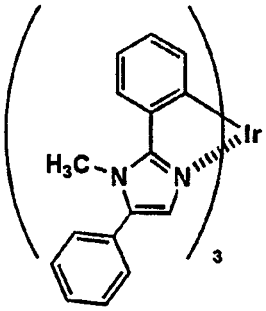
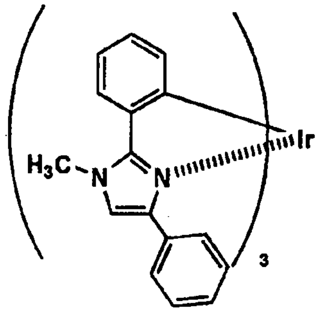


D-53



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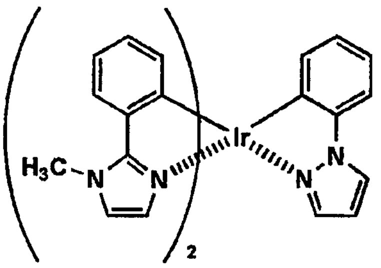
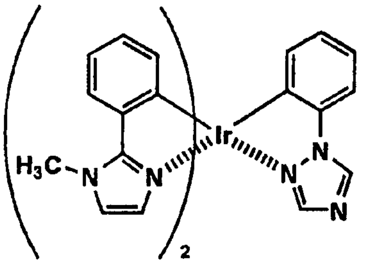
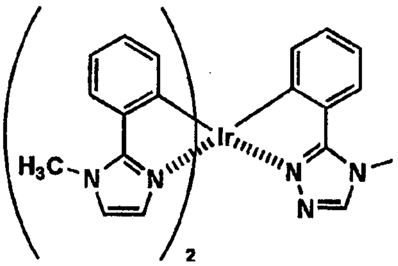


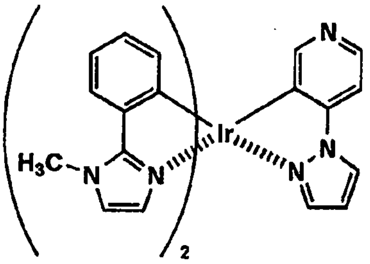
D-55



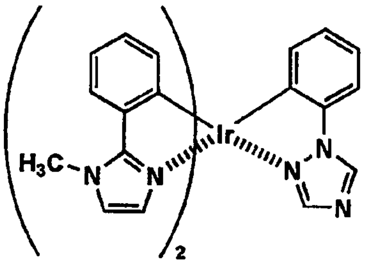
D-56



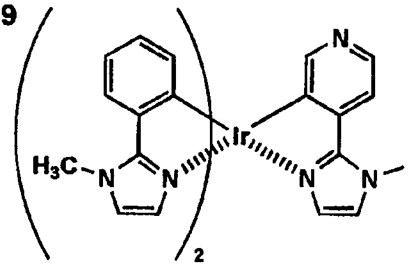
D-57



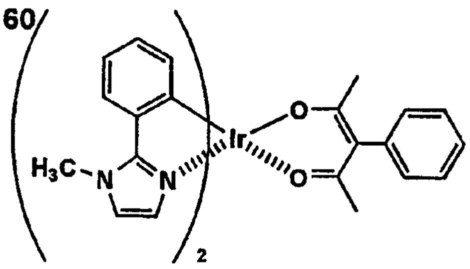
D-58



D-59



D-60



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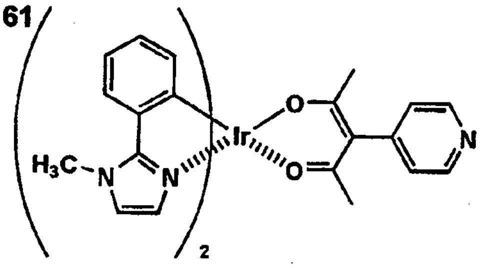

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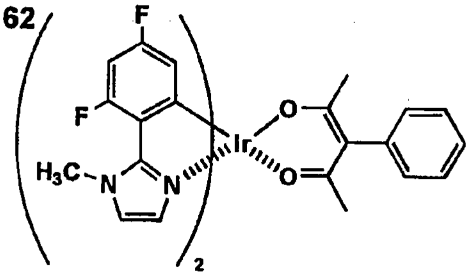
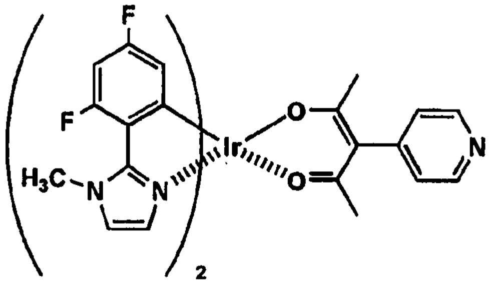
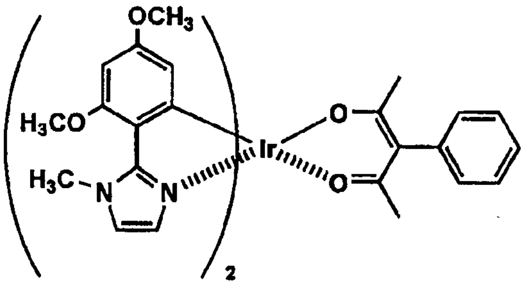


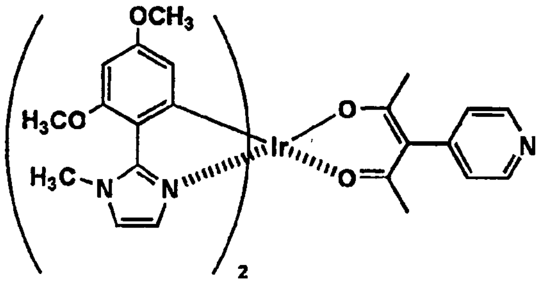
D-63



D-64



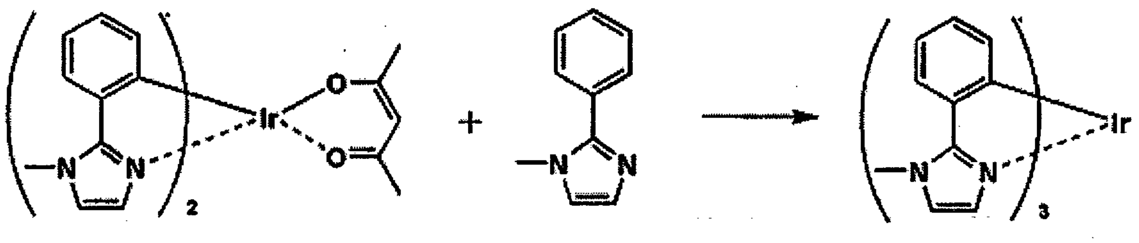
D-65



[0099] Synthesis of a compound having the partial structure represented by Formulae (A) to (C) is described below.

Synthesizing example D-1

[0100]



D−1acac **D−1**

[0101] In to a 500 ml three-mouth flask, 4.0 g of D-lacac, 2.6 g of phenylimidazole and 300 ml of glycerol were charged. A thermometer and a cooler were attached onto the flask. The flask was set on an oil bath stirrer and the temperature of the bath was controlled so that the content of the flask was gradually heated and held at 150 °C. The content of the flask was stirred for 5 hours for completing the reaction. Crystals were precipitated by cooling the content by room temperature. The reacting liquid was diluted by 200 ml of methanol and the crystals were separated by filtration and sufficiently washed by methanol and dried. Thus 1.6 g (36. 5%) of product was obtained. It was confirmed by ^{1}H-NMR and MASS that the crystals obtained were D-1.

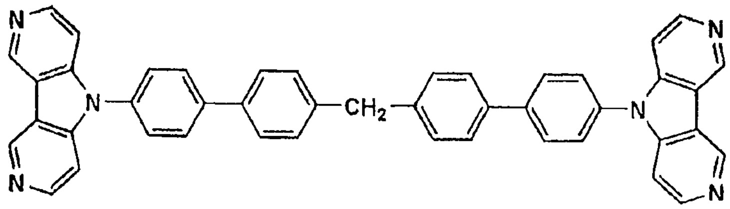
(Light emission host)

[0102] The light emission host (also simply referred to as host) is a compound having the highest content by weight in the two or more compounds constituting the light emission layer and a compound other than the host referred to as a dopant compound (also simply referred to as dopant). For instance, when the light emission layer is constituted by Compound A and Compound B and the ratio of A to B is 10:11, Compound A is the dopant compound and compound B is the host compound. When the light emission layer is constituted by three Compounds A, B and C and the ratio of A:B:C is 5:10:85; Compounds A and B are the dopant compounds and Compound C is the host compound.

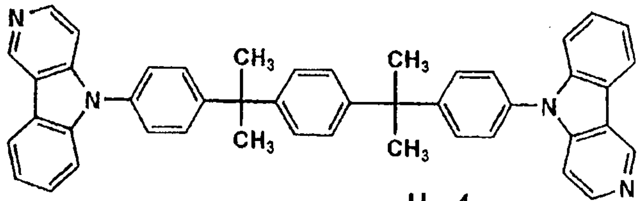
[0103] The light emission host to be used in the present invention is a carbazole derivative.

[0104] Examples of carboline derivatives and diazacarbazole derivatives used for comparative purposes are listed below (H1-H13). Carbazole hosts used in the Examples are H14-H16.

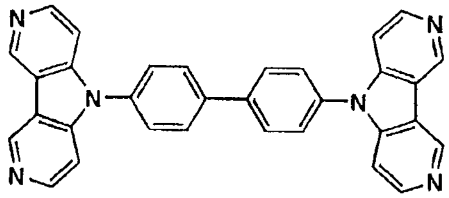
H-1



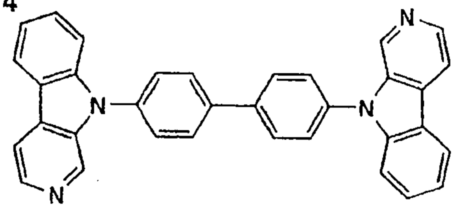
H-2



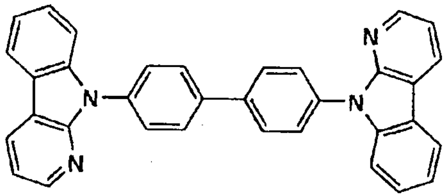
H-3



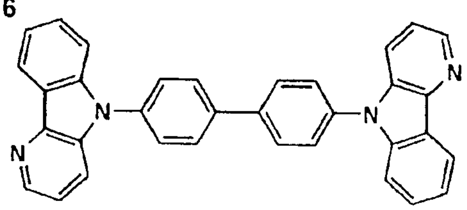
H-4



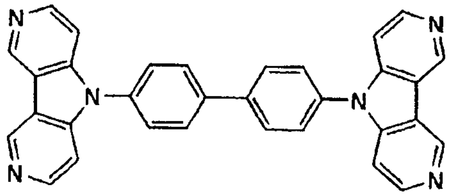
H-5



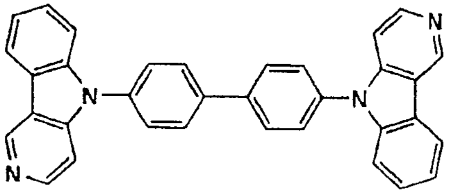
H-6



H-7



H-8



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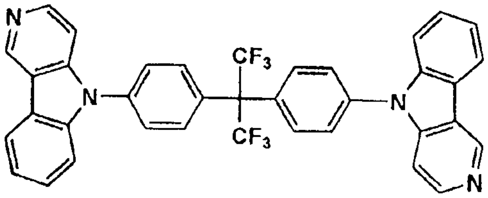

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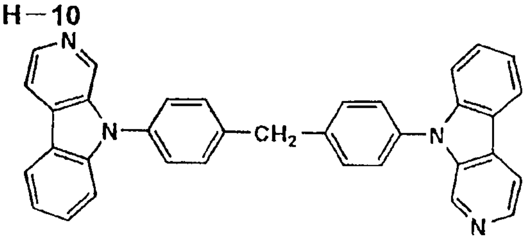

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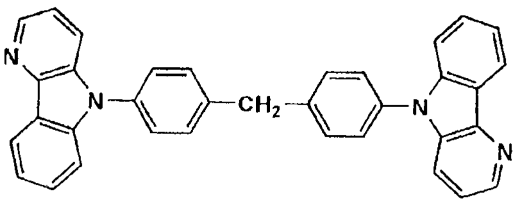

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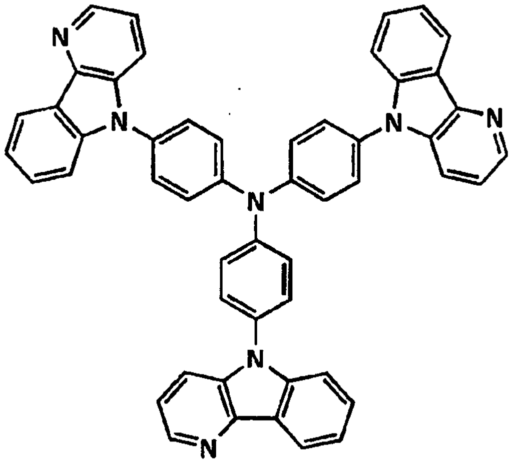
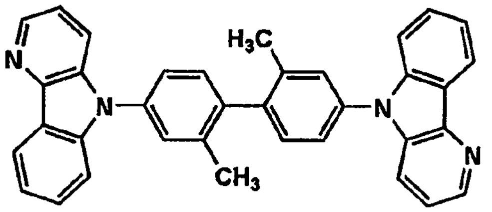
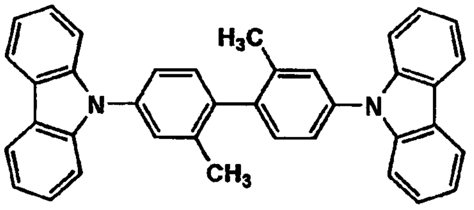


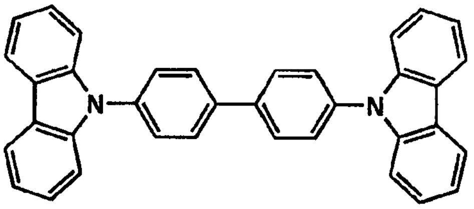
H−13



H−14



H−15



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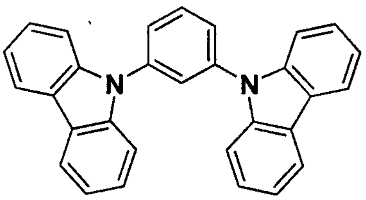


[0105] The host compound to be used in the present invention may be either a low molecular weight compound or a high molecular compound having repeating units. A low molecular weight compound having a polymerizable group such as a vinyl group and an epoxy group (vapor depositing polymerizable light emission host) may also be used.

[0106] As the light emission host, a preferred compound has hole transport ability, electron transport ability and ability to prevent the prolongation of the wavelength of emitting light and a high glass transition point Tg.

[0107] As examples of the light emission host, the carbazole compounds described in the following publications are suitable. For example, JP-A Nos. 2001-257076, 2002-308855, 2001-313179, 2002-319491, 2001-357977, 2002-334786, 2002-8860, 2002-334787, 2002-15871, 2002-334788, 2002-43056, 2002-334789, 2002-75645, 2002-338579, 2002-105445, 2002-343568, 2002-203683, 2002-363227, 2002-231453, 2003-3165, 2002-234888, 2003-27048, 2002-255934, 2002-260861, 2002-280183, 2002-299060, 2002-302516, 2002-305083, 2002-305084 and 2002-308837

<<Production method of light emission layer>>

[0108] The production method of the light emission layer relating to the present invention is described below with reference to Fig. 7 and 8 but the present invention is not limited to them.

[0109] For example, in each of three kinds of crucible 204a, 204b and 204c were charged the light emission dopants respectively and in a crucible were charged the compound for the host material and the intermediate layer forming material. Each crucible may be a heating boat.

[0110] The speed of vapor deposition of the dopants or the host material and the intermediate layer forming material are suitably controlled by heating each of the vapor sources. Therefore, a shutter 202 was provided for optionally shutting the vapor deposition.

[0111] The shutter for vapor deposition of the host material and the intermediate layer forming material is usually opened and not closed. The shutters 202 each provided to the light emission dopant evaporation crucible 203 is closed or opened as required so as to control the co-deposition condition.

[0112] The light emission layer is formed by vapor deposition when the shutter is opened and the intermediate layer can be formed by deposition when the shutters 202 for the dopants are entirely closed.

[0113] To date the vapor sources for deposition corresponding to the kinds of the material are necessary in the production of intermediate layer when the materials for forming each of the layers are different from each other. Moreover, it is very difficult to suitably control each of the deposition conditions. These are large problems in the production process.

[0114] In the present invention, the depositing condition for forming the layer can be changed by opening and closing the one shutter even when many light emission layers are to be formed. Therefore, a light emission layer having many laminated layers such as those shown in Figs. 10 to 13 can be easily formed.

[0115] Fig. 8 shows an example in which the host material and the intermediate layer forming material, 206a and 206b, are arranged between vaporization crucibles 203 respectively charged with the light emission dopants 205a, 205b and 205c.

[0116] In a simpler method in which the dopant and the host material to be also used as the intermediate layer forming material are vaporized from the vapor sources arranged in parallel as shown in Fig. 8.

[0117] The same layer constitution can be produced by moving (go and return in right and left directions) the substrate at a designated speed.

[0118] Such a method is also carried out by using the material commonly applied for the host material and the intermediate layer forming material.

<<Intermediate layer>>

[0119] The intermediate layer relating to the present invention is described below.

[0120] In the present invention, the intermediate layer is characterized in that the material for forming the intermediate layer is in common with the host compound contained in the light emission layer (the host compound is described later). By commonly using the material for the light emission layer and for the material of the intermediate layer effects such as the injection barrier between the light emission layer and the intermediate layer can be lowered and the injection balance of positive hole and electron can be easily held even when the applying voltage (current) is varied. It is further found that the chromaticity deviation by applying voltage (electric current) can be improved. Moreover the complexity of the production process of an element having the intermediate layer is a serious problem which can be solved by using common material.

[0121] When many light emission layers are cyclically or randomly laminated as shown in Figs. 10 to 13 and the host material is different from the intermediate layer, the production process is very complicated. Such a process can be considerably simplified by commonly using the same material according to the present invention.

[0122] Moreover the triplet exciton in the light emission layer can be effectively confined in the light emission layer by using a material having triplet excitation energy higher than that of the phosphorescent compound and an element showing high efficiency can be obtained.

[0123] The Förster energy transfer between the light emission layers different from each other can be inhibited by setting the thickness of the intermediate layer to be greater than the Förster distance so that the chromaticity deviation can be inhibited and an element with high efficiency can be obtained.

[0124] Known materials can be used for forming the intermediate layer and the host material (the host material is described later). For the intermediate layer material and the host material, a preferred material has the triplet excitation energy higher than that of the phosphorescent compounds having highest triplet excitation energy among the phosphorescent compounds. For example, in an element emitting white light composed of blue, green and red color light, when phosphorescent compounds are used for each of the color light emitting material, the triplet excitation energy of the blue light emitting compound is highest. The preferred material for the intermediate layer and for the host material has a larger triplet excitation energy than the blue light emitting compound.

[0125] In the organic EL element, the material for the intermediate layer and host material performs transportation of the carrier. Therefore a material having carrier transport ability is preferred. Carrier mobility is used for expressing the carrier transportation ability, and the carrier transport ability of organic material is usually dependent on the electric field strength. In a material having high electric field strength dependency, the balance of the injection and transportation of the positive hole and the electron tends to be lost. Accordingly a material with low electric field dependency is preferred as the material for the intermediate layer and host material.

[0126] A typical structure of the organic EL element is described below.

<<Layer constitution of the organic EL element>>

[0127] Specific examples of the layer constitution of the organic EL element of the present invention are described below but the present invention is not limited to them.

(i) Anode/Hole transport layer/Light emission layer/Hole blocking layer/Electron transport layer/Cathode
(ii) Anode/Electron blocking layer/Light emission layer/Hole blocking layer/Electron transport layer/Cathode
(iii) Anode/Hole transport layer/Electron blocking layer/Light emission layer/Hole blocking layer/Electron transport layer/Cathode
(iv) Anode/Hole transport layer/Electron blocking layer/Light emission layer/Hole blocking layer/Electron transport layer/Cathode
(v) Anode/Hole transport layer/Electron blocking layer/Light emission layer/Hole blocking layer/Electron transport layer/Cathode buffer layer/Cathode
(vi) Anode/Anode buffer layer/Hole transport layer/Electron blocking layer/Light emission layer/Hole blocking layer/Electron transport layer/Cathode buffer layer/Cathode
(vii) Anode/Anode buffer layer/Hole transport layer/Electron blocking layer/Light emission layer/Hole blocking layer/Electron transport layer/Cathode buffer layer/Cathode

<<Blocking layer (electron blocking layer, hole blocking layer)>>

[0128] The blocking layer (such as the electron blocking layer and the hole blocking layer) relating to the present invention is described below.

[0129] In the present invention, the material for the organic EL element of the present invention is preferably used for the hole blocking layer and the electron blocking layer and particularly preferably used for the hole blocking layer.

[0130] When the material of the organic EL element of the present invention is contained in the hole blocking layer or the electron blocking layer, the metal complex described in any one of Claims 1 to 14 may be contained in a content of 100% by weight or in a state of mixture with another organic compound such as the compound used in the layer constituting the organic EL element of the present invention.

[0131] The thickness of the blocking layer relating to the present invention is preferably 3 nm to 100 nm and more preferably 5 to 30 nm.

<<Hole blocking layer>>

[0132] The hole blocking layer has the function of the electron transport layer in a wide sense and is comprised of a material which has electron transport ability and very low hole transport ability. The probability of recombination of the electron with the hole can be raised by the ability of such a material to block the hole whilst transporting the electron.

[0133] The hole blocking layer described in, for example, JP-A Nos. 11-204258 and 11-204359, and "Yuuki EL soshi to sono kougyouka saizennsenn (Organic EL element and its front of industrialization) November 30, 1998 can be applied as the hole blocking layer in the present invention. Moreover, the later-mentioned electron transport layer relating to the present invention can be used as the hole blocking layer in the present invention as required.

<<Electron blocking layer>>

[0134] The electron blocking layer comprises a material having a function of hole transportation in a wide sense while having very low ability of electron transportation. The probability of recombination of the electron with the hole can be raised by blocking the electron whilst transporting the hole. The constitution of the later-mentioned hole transport layer can be used as the electron blocking layer as required.

[0135] In the present invention, the material of organic EL element of the present invention is preferably used in the layer adjacent to the light emission layer, namely the hole blocking layer or the electron blocking layer, particularly in the hole blocking layer.

<<Hole transport layer>>

[0136] The hole transport layer contains a material having hole transport ability and includes in a wide sense a hole injection layer and the electron blocking layer. The hole transport layer may be provided singly or plurally.

[0137] The positive transportation material is not specifically limited and can be optionally selected from materials usually used as a charge injection material for hole and known materials used for the hole injection layer or the hole transport layer.

[0138] The material of the hole transport layer is one capable of hole injection or transportation or of being an electron barrier and may be an inorganic or organic substance. Examples of such material include a triazole derivative, an oxadiazole derivative, an imidazole derivative, a polyarylalkane derivative, a pyrazoline derivative, a pyrazolone derivative, a phenylenediamine derivative, an arylamine derivative, an amino-substituted chalcone derivative, an oxazole derivative, a styrylanthracene derivative, a fluorenone derivative, a hydrazone derivative, a stilbene derivative, a silazane derivative, an aniline type copolymer and an electroconductive high molecular weight oligomer particularly a thiophene oligomer.

[0139] The above-mentioned can be used as the material of the hole transport layer, and a porphyline compound, an aromatic tertiary amine compound and a styrylamine compound particularly an aromatic tertiary amine compound are preferably used.

[0140] Typical examples of the aromatic tertiary amine compound and the styrylamine compound include N,N,N',N'-tetrapphenyl-4,4'-diaminophenyl; N,N'-diphenyl-N,N'-bis(3-methylphenyl)-[1,1'-biphenyl]-4,4'-diamine (TPD); 2,2-bis(4-dip-triaminophenyl)propane; 1,1-bis(4-di-p-triaminophenyl)-cyclohexane; bis(4-dimethylamino-2-methylphenyl)-phenylmethane; bis(4-di-p-triaminophenyl)phenylmethane; N,N'-diphenyl-N,N'-di(4-methoxyphenyl)-4,4'-diamonobiphenyl; N, N,N',N'-tetraphenyl-4,4'-diamonodiphenyl ether; 4,4'-bis(diphenylamino)quadriphenyl; N,N,N-tri(p-tolyl)amine; 4-(di-p-tolylamino)-4'-[4-(di-p-tolylamino-4'-[4-(di-p-tolylamino)styryl]stilbene; 4-N,N-diphenylamino-(2-diphenylvinyl)benzene; 3-methoxy-4'-N,N-diphenylaminostilbenzene; N-phenylcarbazole; ones having two condensed aromatic rings in the molecular thereof described in U.S. Patent No. 5,061,569 such as 4.4-bis[N-(l-naphthyl)-N-phenylamino]biphenyl (NPD), and ones in which three triphenylamine units are bonded in star burst state described in JP-A No. 4-308688 such as [N-(3-methylphenyl)-N-phenylamino]triphenylamine (MTDATA).

[0141] Polymer materials can be also used in which the above material is introduced in the main chain thereof or the main chain is formed by the above material.

[0142] Inorganic compounds such as p-type-Si, p-type SiC are also usable as the hole injection material or the hole transportation material. The hole transportation material preferably has high Tg.

[0143] The hole transport layer can be formed by making the above hole transportation material as a thin layer by a known method such as a vacuum vapor deposition method, a spin coat method, a casting method, an ink-jet method or a BL method. The thickness of the hole transport layer is usually approximately 5 nm to 5,000 nm even though the thickness is not specifically limited. The hole transport layer may be a single layer comprising one or two or more kinds of the above material.

[0144] A highly p-type hole transport layer doped with an impurity can also be used. Examples of that are described in JP-A Nos. 4-297076, 2000-196140 and 2001-102175, and J. Appl. Phys., 95, 5773 (2004).

<<Electron transport layer>>

[0145] The electron transport layer comprises a material having electron transport ability and includes the electron injection layer and the hole blocking layer in a wide sense. The electron transport layer may be provided singly or plurally.

[0146] To date the following materials are used as materials serving both of electron transportation and the hole blocking in the electron transport layer adjacent to the cathode side of the light emission layer when single or plural electron transport layers are provided.

[0147] The electron transport layer has a function of transporting the electron injected from the cathode to the light emission layer and the material thereof may be optionally selected from known compounds.

[0148] Examples of the material to be used in the electron transport layer (hereinafter referred to as electron transportation material) include a heterocyclic tetracarboxylic acid anhydride such as a nitro-substituted fluorene derivative, a diphenylquinone derivative, a thiopyrane dioxide derivative and naphthaleneperylene, carbodiimide, a fluorenylidenemethane derivative, a derivative of anthraquinonedimethane or anthrone and an oxadiazole derivative. Moreover, a thiadiazole derivative formed by substituting the oxygen atom in the above oxadiazole derivative and a quinoquizaline derivative having a quinoquizaline ring known as an electron withdrawing group are usable as the electron transportation material.

[0149] A polymer material in which the above material is introduced in the main chain thereof or forms the main chain thereof is also usable.

[0150] A metal complex of 8-quinolinol such as tris(8-quinolinol)aluminum (Aiq), tris(5,7-dichloro-8-quinolinol)aluminum, tris(5,7-dibromo-8-quinolinol)-aluminum, tris(2-methyl-8-quinolinol)aluminum, tris(5-methyl-8-quinolinol)aluminum, bis(8-quinolinol)zinc (Znq) and complexes of the above in which the center metal is replaced by In, Mg, Cu, Cs, Sn, Ca or Pb are usable for electron transportation. Moreover, a metal free or metal-containing phthalocyanine and ones formed by substituting the terminal thereof by a substituent such as an alkyl group or a sulfonic acid group can be preferably used as the electron transportation material. The styrylpirazine derivatives exemplified as the material for the light emission layer are usable and inorganic semiconductors such as n-type Si and n-type SiC are also usable as the electron transportation material.

[0151] The electron transport layer can be formed by making the above electron transportation material into a thin layer by a known method such as vacuum vapor deposit method, a spin coating method, a casting method and a LB method. The thickness of the electron transport layer is usually about 5 to 5,000 nm though the thickness is not specifically limited. The electron transport layer may be a single layer comprising one or two or more kinds of the above-mentioned materials.

[0152] A highly n-type hole transport layer doped with an impurity can also be used. Examples of that are described in JP-A Nos. 4-297076, 2000-196140, 2001-102175, and J. Appl. Phys., 95, 5773 (2004).

[0153] The injection layer to be used as a constitution layer of the organic EL element of the present invention is described below.

<<Injection layer>>: Electron injection layer, Hole injection layer

[0154] The injection layer is classified into an electron injection layer and a hole injection layer which are provided as required. The injection layer may be provided between the anode and the light emission layer or hole transport layer, or between the cathode and the light emission layer or electron transport layer.

[0155] The injection layer is a layer provided between the electrode and the organic layer for lowering the driving voltage or raising the luminance of emitted light. The injection layer is described in detail in "Yuuki EL soshi to sono kougyouka saizennsenn (Organic EL element and its Front of Industrialization) Vol. 2, Sect. 2, "Electrode materials" pp. 123 to 166, November 30, 1998, published by NTS Co., Ltd., and includes a hole injection layer (an anode buffer layer) and an electron injection layer (a cathode buffer layer).

[0156] The anode buffer layer (hole injection layer) is described in detail in JP-A Nos. 9-45479, 9-260062 and 8-288069 and specific examples thereof include a phthalocyanine buffer layer typically copper phthalocyanine, an oxide buffer layer typically vanadium oxide, an amorphous carbon buffer layer and a polymer buffer layer using polyaniline (emeraldine) or polythiophene.

[0157] The cathode buffer layer (electron injection layer) is also described in detail in JP-A Nos. 6-325871, 9-17574 and 10-74586, and examples thereof include a metal buffer layer typically strontium and aluminum, an alkali metal compound buffer layer typically lithium fluoride, an alkali-earth metal compound buffer layer typically magnesium fluoride and an oxide buffer layer typically aluminum oxide.

[0158] The buffer layer (injection layer) is desirably an extremely thin layer and the thickness thereof is preferably 5 to 5,000 nm according to the kind of material. The injection layer is may have a single layer structure comprising one or two or more kinds of the material.

<<Anode>>

[0159] The anode relating to the organic EL element of the present invention is preferably one comprising a metal, an alloy, an electroconductive compound or a mixture thereof each preferably having high work function (not less than 4 eV). Examples of such the electrode material include a metal such as Au and an electroconductive transparent material such as CuI, indium tin oxide (ITO), SnO_2, and ZnO. An amorphous material capable of forming a transparent electrode layer such as IDIXO (In_2O_3-Zn) is usable. The anode may be formed by making a thin layer of such electrode material by a method such as a vapor deposition or a spattering method and pattering to the desired form by a photolithographic method. The vapor deposition or spattering of the electrode material may be performed through a mask of desired pattern to form the pattern of the electrode when high precision is not so necessary. When the light is putout through the anode, the transparency of the anode is preferably not less than 10% and the sheet resistivity is preferably not more than several hundred Ω/□. The layer thickness is usually 10 nm to 1,000 nm and preferably 10 nm to 200 nm.

<<Cathode>>

[0160] On the other hand, the cathode relating to the present invention is one comprising a metal (referred to as an electron injective metal), an alloy or an electroconductive compound each having low working function (not more than 4 eV) or a mixture thereof. Specific examples of such electrode material include sodium, sodium-potassium alloy, magnesium, lithium, a magnesium/copper mixture, a magnesium/silver mixture, a magnesium/aluminum mixture, a magnesium/indium mixture, an aluminum/aluminum oxide (Al_2O_3) mixture, indium, a lithium/aluminum mixture and a rare-earth metal. A mixture of an electron injective metal and a second metal larger in the working function and stability than the electron injective metal such as a magnesium/silver mixture, magnesium/indium mixture, aluminum/aluminum oxide (Al_2O_3) mixture, lithium/aluminum mixture and aluminum are suitable from the viewpoint of the electron injecting ability and stability to oxidation. The cathode can be formed by making the electrode material into a thin layer by a method such as a vapor deposition method or a spattering method. The sheet resistivity of the cathode is preferably not more than several hundred Ω/□ and the thickness thereof is usually selected within the range 10 nm to 1,000 nm, preferably

50 nm to 200 nm. It is suitable for raising the luminance of the emitted light that at least one of the anode and cathode is transparent or semi-transparent.

<<Substrate (also referred to as base plate, base material or support)>>

[0161] There is no limitation on the kind of substrate (such as glass and plastics) relating to the organic EL element of the present invention as long as it is transparent. Glass, quartz and light permeable resin film are preferred. Particularly preferably the substrate is a resin film which can give flexibility to the organic EL element.

[0162] The resin film may be for example a film comprising polyethylene terephthalate (PET), polyethylene naphthalate PEN), polyether sulfone (PES), polyetherimide, poly(ether ether ketone), poly(phenylene sulfide), polyallylate, polyimide, polycarbonate (PC), cellulose triacetate (TAC) or cellulose acetate propionate.

[0163] A layer of inorganic substance or an organic substance or a hybrid layer thereof may be formed on the surface of the resin film. The film is preferably one having high barrier ability of a steam permeability of not more than 0.01 $g/m^2 \cdot day \cdot atm$.

[0164] The output efficiency at room temperature of emitted light of the organic EL is preferably not less than 1% and more preferably not less than 2%, wherein the output efficiency is expressed as follows: External Quantum Efficiency (%) = Number of photon emitted from organic EL element to exterior/Number of electron applied to organic EL element x 100.

[0165] A hue improvement filter such as a color filter may be used.

[0166] A film having a roughened surface such as an anti-glaring film also can be used for reducing the unevenness of light emission when the element is used for lighting.

[0167] When the element is used for a multi-color display, the apparatus has at least two kinds of organic EL elements having different emission peak wavelengths from each other. A suitable example of the production of the organic EL is described below.

<<Production method of organic EL element>>

[0168] As an example of a production method of the organic EL element of the present invention having the constitution Anode/Hole injection layer/Hole transport layer/Light emission layer/Hole blocking layer/Electron transport layer/Cathode buffer layer/Cathode is described below.

[0169] On a suitable substrate, a thin layer of a desired electrode material such as the anode material is formed by a method such as vapor deposition or spattering so that the layer thickness is preferably within the range 10 nm to 200 nm to form an anode. On the anode, thin layers such as the hole injection layer, the hole transport layer, the light emission layer and the hole blocking layer are formed.

[0170] For forming the thin layer containing the organic compound, the spin coating method, casting method, ink-jet method, vapor deposition method and printing method are applicable. The vacuum vapor deposition method and spin coating method are particularly preferred from the viewpoint that a uniform layer can be easily formed and pin-hole is difficult to form. Different layer forming methods may be applied for each of the layers. When the thin layers are formed by the vapor deposition method, it is desirable that the deposition conditions are suitably selected from the range of boat heating temperature of 50 °C to 450 °C, vacuum degree of 10^{-6} Pa to 10^{-2} Pa, a deposition rate of 0.01 nm to 50 nm/second, a substrate temperature of -50 °C to 300 °C and a layer thickness of 0.1 nm to 5 μm.

[0171] After formation of these layers, the cathode is provided on the layer by a method such as vapor deposition and spattering so the thickness becomes not more than 1 μm and preferably from 50 nm to 200 nm to obtain the desired organic EL element. It is preferred that the formation of the hole injection layer to the cathodes is consistently performed by once evacuation but it is allowed that the element is take out on half way for subjecting to a different layer formation procedure. In such a case, it is necessary that the operation is carried out under an inert gas atmosphere.

<<Display>>

[0172] The display is described below.

[0173] Although the display of the present invention may be mono-color or multi-color, a multi-color display is described here. In the case of a multi-color display, a shadow mask is only applied at the formation of light emission layer and the other layers can be uniformly formed by the vapor deposition method, casting method, spin coating method, ink-jet method or printing method.

[0174] Although the method is not specifically limited, when the light emission layer is only patterned, patterning by the vapor deposition method, ink-jet method or printing method is preferred.

[0175] The order of layer formation may be reversed so that the order becomes cathode, electron transport layer, hole blocking layer, light emission layer, hole transport layer and anode.

[0176] Light emission can be observed when a DC voltage of about 2 to 40 V is applied to the element so that the polarity of the anode is positive and that of the cathode is negative. If the polarity is reversed, the electric current is not caused and light is not emitted at all. When AC voltage is applied, light is emitted only at the time when the anode is positive and cathode is negative. The wave shape of the AC voltage to be applied may be optional.

[0177] The multi-color display can be applied as a displaying device, a display and various lighting sources. In the displaying device and display, full color image can be displayed by the use of three kinds of organic EL elements emitting blue, green and red light.

[0178] Examples of the displaying device and display are a television, a personal computer, a mobile apparatus, an AV apparatus, a display for letter broad casting and a display attached in car. The apparatus may be used for reproducing a still image and a moving image. When the apparatus is used for displaying a moving image, a simple matrix (passive matrix) system or an active matrix system may be applied.

[0179] As the lighting source, the element can be applied but is not limited to domestic lighting, car lighting, a backlight for a watch or a liquid crystal display, a light for a sign board, a signal light, a light source for a light memory medium, a light source of an electrophotographic copy machine, a light source of a light communication apparatus and a light source for a photo-sensor.

<<Illuminator>>

[0180] The illuminator according to the present invention is described below.

[0181] The organic EL element of the present invention may be used as an organic EL element having a resonator structure therein. Such an organic EL element having resonator structure can be used as (for example) a light source of a light memory medium, a light source of an electrophotographic copying machine, a light source of a light communication apparatus and a light source for light sensor. The element can be used for the above-mentioned use by oscillating a laser.

[0182] The organic EL element of the present invention may be used as a lamp such as a lighting light source and the exposing light source and as a projection apparatus for projecting an image or a display for directly watching a still or a moving image. The driving system for displaying the moving image may be either a simple matrix (passive matrix) system or an active matrix system. A full color display can be produced by using two or more kinds of organic EL element of the present invention each different from each other in the color of emitting light.

[0183] An example of a display having the organic EL element of the present invention is described below with reference to the drawings.

[0184] Fig. 1 shows a schematic drawing of an example of display constituted by the organic EL element. The schematic drawing shows an apparatus for displaying image information by emitted light from the organic EL element such as a display of a portable telephone.

[0185] Display 1 comprises a display A having plural pixels and a controlling device B for scanning the display 1 according to image information.

[0186] The controlling device B electrically connected to the display A sends scanning signals and image data to each of the plural pixels according to image information sent from outside. The pixels of each of the scanning line successively emit light by the scanning signals each corresponding to image date signals to display the image information on the display A.

[0187] Fig. 2 shows a schematic drawing of the display A.

[0188] The display A has wiring including plural lines for scanning 5 and that for data 6 and plural pixels 3 on a substrate. Principal parts of the display A are described below.

[0189] In the drawing, light emitted from the pixel 3 is taken out in the direction of the white arrow (downward).

[0190] The scanning lines 5 and the data lines 6 are each composed of an electroconductive material and the scanning line and the date line are crossed in lattice form at a right angle as a lattice and connected to the pixel 3 at the crossing point (detail is not shown in the drawing).

[0191] The pixel 3 receives image data from the date line 6 when the scanning signal is applied from the scanning line 5 and emits light corresponding to the image data. A full color image can be displayed by arranging pixels emitting red range light, green range light and blue range light on the same substrate.

[0192] When white light emitting organic EL elements are used, full color display can be performed by using B, G and R color filters.

[0193] The light emitting process of the pixel is described below.

[0194] Fig. 3 shows a schematic drawing of the pixel.

[0195] The pixel has the organic EL element 10, a switching transistor 11, a driving transistor 12 and a condenser 13. Full color display can be realized by using the white light emitting organic EL element divided into plural pixels combined with B, G and R color filters.

[0196] In Fig. 3, the switching transistor is turned ON when the date signals are applied to the drain of the switching transistor from the controlling device B through the data line 6 and the scanning signals are applied to the gate of the switching transistor 11 from the controlling device B through the scanning line 5 so that the date signal applied to the drain is transferred to the condenser 13 and the gate of the driving transistor 12.

[0197] The condenser 13 is charged according to the potential of the image data and the driving of the driving transistor 12 is turned ON by the transfer of the image data signal. The drain of the driving transistor is connected to the power source line 7 and the source of that is connected to the electrode of the organic EL element 10. Electric current is supplied from the power source line 7 to the organic EL element 10 corresponding to the potential of the image data signal applied to the gate.

[0198] The driving of the switching transistor 11 is turned OFF when the scanning signal is moved to the next scanning line 5 by the successive scanning by the controlling device B. However, the light emission by the organic EL element 10 is continued until next scanning signal is applied since the driving of the driving condenser is kept at ON state even when the switching transistor is turned OFF because the condenser 13 holds the charged potential. When the next scanning signal is applied by successive scanning, the driving transistor 12 is driven corresponding to the potential of the image data signals synchronized with the scanning signals and the organic EL element 10.

[0199] The organic EL element 10 of each of the plural pixels 3 emits light by providing the switching transistor 11 as an active element and the driving transistor 12 to the organic EL element 10 of each of the plural pixels. Such a light emission system is called as the active matrix system.

[0200] The light emission of the organic EL element 10 may be light emission with gradation corresponding to multi-value data signal having plural gradation potentials or on-off of the designated light amount according to the bi-value image data signal.

[0201] The potential of the condenser 13 may be held until application of the next scanning signal or discharged just before the application of the next scanning signal.

[0202] In the present invention, the light emission may be preformed according to the passive matrix system, not limited to the active matrix system, in which the light is emitted according to the data signal only when the scanning signal is supplied.

[0203] Fig. 4 shows a schematic drawing of a display by the passive matrix system. In Fig. 4, plural scanning lines 5 and the plural image data lines 6 are separately provided on both sides of the pixel 3 so as to face to each other for forming lattice state.

[0204] When the scanning signal is applied to the scanning line 5 by successive scanning, the pixel 4 connected to the scanning line to which the signal is applied emits light corresponding to the image data signal. In the passive matrix system, any active element is not necessary and the production cost can be reduced.

[0205] The materials of the organic EL element relating to the present invention can be applied for an organic EL element emitting substantially white light as an illuminator. The white light is obtained by mixing plural color light simultaneously emitted by plural light emission materials. The combination of the plural color light may be a combination containing three maximum wavelengths of the three primary colors of blue, green and red or a combination containing two maximum wave length of blue and yellow or complementary colors such as blue and yellow or bluish green and orange.

[0206] The combination of the light emission materials for obtaining the plural colors light may be a combination of plural materials capable of emitting phosphorescent light or fluorescent light (fluorescence dopant) or a combination of the material capable of emitting fluorescent or phosphorescent light and a dye capable of emitting light by excitation by the light emitted from the above light emitting material. In the white light emitting organic electro luminescent element, the combination of plural kinds of light emitting dopant is preferred.

[0207] The plural kinds of dopant may be contained in one light emission layer. The element may have plural light emission layers and the dopants different from each other in wavelength of the emitting light are each contained in respective layers. Fine pixels each emitting different wavelength light may be formed in a matrix state.

[0208] In the white light emitting organic electroluminescent element relating to the present invention, patterning may be carried out as required by a metal mask or an ink-jet printing method. The patterning treatment may be given only to the electrode, to the electrode and the light emitting layer or to the layers of the element in their entirety.

[0209] The light emission material to be used in the light emission layer is not specifically limited. For instance, in the case of the backlight for the liquid crystal displaying element, the materials may be selected from the platinum complexes relating to the present invention and known light emission materials are combined so that the emitted white light is suited to the wavelength range corresponding to the property of the color filter.

[0210] As above-described, the white light emitting organic EL element of the present invention can be usefully applied for domestic lighting and car room lighting as various kinds of light source and illuminators, and for a light source for exposing as a kind of lamp and for displays such as the backlight of the liquid crystal display additionally to the displaying device and the display.

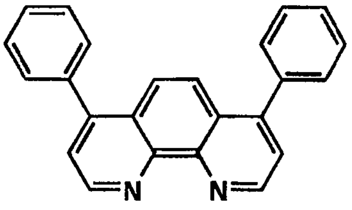
[0211] Additional to the above, various uses can be mentioned such as a backlight of a watch, an advertising signboard, a signal, a light source for a light memory media, a light source for an electrophotographic copier, a light source for a light communication apparatus, a light source for a light sensor and a domestic electric apparatus having a display means.

EXAMPLES

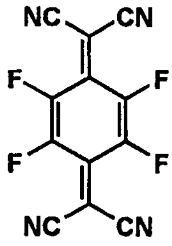
[0212] The present invention is described below referring to examples but the present invention is not limited thereto.

[0213] Structures of the compounds used in the examples are shown below.

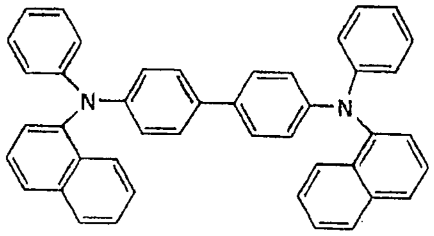
BPhen



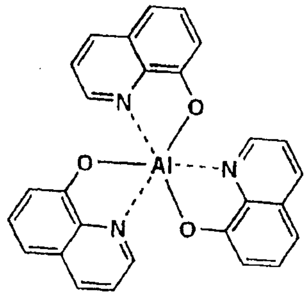
F4−TCNQ



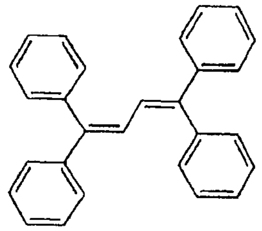
α−NPD



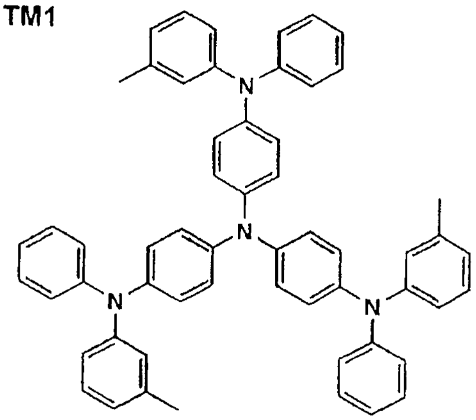
Alq$_3$



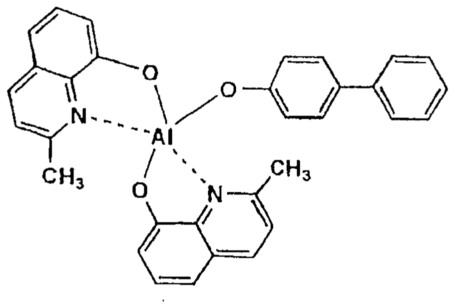
TPB



HTM1



BAlq



Example 1

<<Preparation of Organic EL element 1-1>>

[0214] A layer of ITO (indium oxide) having a thickness of 100 nm formed on a glass substrate plate of 100 mm x 100 mm x 1.1 mm (NA45 manufactured by NH Technoglass Co., Ltd.) was subjected to a patterning treatment to prepare an anode. The transparent substrate plate carrying the ITO transparent electrode was washed by ultrasonic wave using isopropyl alcohol, dried by dried nitrogen gas and cleaned by UV-ozone cleaning for 5 minutes. The resultant transparent substrate was fixed on a substrate holder of a vacuum vapor deposition apparatus available on the market. The crucibles in the vapor deposition apparatus were arranged as shown in Fig. 7. Specifically light emission Dopants Ir-12 and Ir-9 were each charged into vapor deposition crucibles 204a and 204b respectively, and CDBP (H14) as the host material and the intermediate layer forming material were charged into the crucible 204d in a suitable amount. The vaporizing crucibles made from a molybdenum resistance heating material were used.

[0215] Vaporizing crucibles respectively charged with NPD, HTM1, H-14 and Alq_3 were separately set which were not shown in the drawing.

[0216] Then the pressure in the vacuum chamber was reduced to 4×10^{-4} Pa and the vaporization crucible containing NPD was heated by applying electric current for depositing NPD on the transparent substrate at a depositing rate of 0.1 nm/second to form a hole transport layer of 25 nm.

[0217] Next, the vaporization crucible containing HTM1 was heated by applying electric current for depositing HTM1 on the transparent substrate in a depositing rate of 0.1 nm/second to form a hole transport layer of 15 nm.

[0218] After that, light emission layer A, an intermediate layer and light emission layer B were formed using the materials shown in Tables 1 and 2 and then a layer of Compound H-14 of 10nm was deposited as a hole blocking layer on light emission layer B.

[0219] Moreover, an electron transport layer of 30 nm was deposited at a rate of 0.1 nm/second by applying electric current to the crucible containing Alq_3.

[0220] The temperature of the substrate was controlled so as to be room temperature.

[0221] After that, 0.5 nm of lithium fluoride layer was deposited as a cathode buffer layer and then 110 nm of aluminum layer as the cathode was deposited to prepare Organic EL Element 1-1.

Preparation of Organic EL Elements 1-2 to 1-14

[0222] Organic EL Elements 1-2 to 1-14 were prepared in the same manner as Organic EL Element 1-1 except that the constitution of the light emission layer (light emission layer and the intermediate layer) was changed as shown in Tables 1 and 2.

Table 1

Element No.	* constitution	* A	* B	*C	Re-marks
1-1	* 1-1	H-14:Ir-12 3 ** 15nm	H-14:Ir-9 8 ** 8nm	None	Inv.
1-2	* 1-4	H-6:Ir-12 3 ** 7nm	H-6:Ir-9 8 ** 5nm	None	Reference
1-3	* 1-6	H-13:Ir-12 3 ** 3nm	H-13:Ir-9 8 ** 2nm	None	Reference
1-4	* 2-2	H-14:Ir-13 3 ** 8nm	H-14:Ir-1 6 ** 4nm	H-14:Ir-9 8 ** 6nm	Inv.
1-5	* 2-5	H-13:Ir-13 3 ** 6nm	H-13:Ir-9 8 ** 2nm	H-13:Ir-1 6 ** 4nm	Reference
1-6	* 2-6	H-14:Ir-13 3 ** 5nm	H-14:Ir-1 6 ** 2nm	H-14:Ir-9 8 ** 3nm	Inv.
1-7	* 2-7	H-13:Ir-13 3 ** 4nm	H-13:Ir-1 6 ** 1.5nm.	H-13:Ir-14 6 ** 2nm	Reference
1-8	* 3-4	H-14:Ir-13 6 ** 5nm	H-14:Ir-9 7 ** 3nm	H-14:Ir-5 7 ** 2nm	Inv.
1-9	* 2-6	H-14:TPB 3 ** 5nm	H-14:Ir-1 6 ** 2nm	H-14:Ir-9 8 ** 3nm	Inv.
1-10	* 1-1	H-15:Ir-12 3 ** 15nm	H-15:Ir-9 8 ** 8nm	None	Comp.
1-11	* 1-1	H-14:Ir-12 3 ** 15nm	H-14:Ir-9 8 ** 8nm	None	Comp.
1-12	* 2-6	H-14:Ir-13 3 ** 5nm	H-14:Ir-1 6 ** 2nm	H-14:Ir-9 8 ** 3nm	Comp.

(continued)

Element No.	* constitution	* A	* B	*C	Remarks
1-13	* 1-1	Ir-14:H-16 11 ** 5nm	H-16:D-49 9 ** 15nm	None	Inv.
1-14	* 2-1	H-16:D-1 9 ** 15nm	Ir-1:H-16 6 ** 2nm	Ir-14:H-16 11** 5nm	Inv.
*: Light emission layer, **: weight-%, Inv.: Inventive, Comp.: Comparative					

Table 2

Element No.	* constitution	* D	Intermediate layer	Remarks
1-1	* 1-1	None	H-14 3nm	Inventive
1-2	* 1-4	None	H-6 all 3nm	Reference
1-3	* 1-6	None	H-13 entirely 3nm	Reference
1-4	* 2-2	None	H-14 between light emission layers A - C 3nm	Inventive
1-5	* 2-5	None	H-13 all 3nm	Reference
1-6	* 2-6	None	H-14 all 3nm	Inventive
1-7	* 2-7	None	H-13 all 3nm	Reference
1-8	* 3-4	H-14:Ir-10 6 weight-% 2nm	H-14 all 3nm	Inventive
1-9	* 2-6	None	H-14 all 3nm	Inventive
1-10	* 1-1	None	BAlq 3nm	Comparative
1-11	* 1-1	None	BAlq 3nm	Comparative
1-12	* 2-6	None	BAlq all 3nm	Comparative
1-13	* 1-1	None	H-16 3nm	Inventive
1-14	* 2-1	None	H-16 3nm	Inventive
*: Light emission layer				

[0223] The external quantum efficiency and the chromaticity deviation of each of Organic EL elements 1-1 to 1-14 were evaluated as follows.

External quantum efficiency

[0224] The external quantum efficiency in percent of each of the organic El elements was measured by constantly applying an electric current of 2.5 A/cm^2 to the element at 23 °C under an atmosphere of nitrogen gas. A spectral irradiance meter CS-1000 manufactured by Minolta Co., Ltd. was used for measurement.

Evaluation of chromaticity deviation

[0225] The deviation of chromaticity is expressed by the difference between the chromaticity at a luminance of 100 cd/m^2 and that at 5,000 cd/m^2 in CIE chromaticity diagrams. The measurement was carried out at 23 °C by CS-1000 manufactured by Minolta Co., Ltd. under a nitrogen gas atmosphere.

[0226] The results are shown in Table 3.

Table 3

Element No.	External quantum efficiency	Chromaticity deviation	Remarks
1-1	170	0.01	Inventive
1-2	140	0.008	Reference

(continued)

Element No.	External quantum efficiency	Chromaticity deviation	Remarks
1-3	150	0.004	Reference
1-4	160	0.01	Inventive
1-5	145	0.008	Reference
1-6	160	0.006	Inventive
1-7	145	0.005	Reference
1-8	165	0.01	Inventive
1-9	135	0.007	Inventive
1-10	100	0.03	Comparative
1-11	115	0.04	Comparative
1-12	80	0.02	Comparative
1-13	172	0.008	Inventive
1-14	175	0.008	Inventive

[0227] It is clear from Table 3 that the elements of the present invention show high external quantum efficiency namely high light emission efficiency and small chromaticity deviation.

Example 2

<<Preparation of Organic EL Element 2-1 to 2-12>>

[0228] Organic EL Elements 2-1 to 2-12 were each prepared in the same manner as Organic EL Elements 1-2 to 1-12 respectively, except that NPD was replaced with a co-deposited layer of HTM1 and F4-TCQ_3 in a ratio of 97:3 and Alq_3 was replaced with a co-deposited layer of BPhen and Ca in a ratio of 1:1 and deposition layer of LiF was omitted. It was confirmed that the driving voltage of Organic EL Elements 2-1 to 2-12 can be lowered by 3 to 6 V compared with Organic EL Elements 1-1 to 1-12.

[0229] From the above-mentioned, it was confirmed that the elements having high energy efficiency (1m/W) can be obtained by the present invention.

Example 3

[0230] The non-light emission surface of Organic EL element 1-6 was covered with a glass sealing can to prepare an illuminator. The illuminator could be used as a thin shaped illuminator capable of emitting white light which had high light emission efficiency and long lifetime. Fig. 6 is a schematic drawing of the illuminator, and (a) is a plan view and (b) is a cross section of the illuminator. The organic EL layer 102 provided on the glass substrate with the electrode 101 was covered by a glass sealing can 104. A UV curable adhesive 107 was used for adhering the glass sealing can. The sign 103 indicates the cathode. The interior of the glass sealing can 104 was filled with nitrogen gas and a moisture catching agent 105 was provided.

[Industrial applicability]

[0231] The organic electroluminescent element, display and illuminator can be provided by the present invention, which displays high external quantum efficiency namely high in the light emission efficiency and low in the deviation of chromaticity.

Claims

1. An organic electroluminescent element comprising an anode; a cathode; at least two light emission layers provided between the anode and the cathode; and at least one intermediate layer provided between the two light emission

layers, wherein
the two light emission layers each comprise the same host compound A;
one of the two light emission layers comprises light emission dopant A and the other light emission layer comprises light emission dopant B which is different from light emission dopant A; and
the intermediate layer comprises host compound A,
wherein host compound A is a carbazole derivative.

2. The organic electroluminescent element of claim 1, wherein at least one of dopants A and B is a phosphorescent compound.

3. The organic electroluminescent element of claim 1, wherein
each of dopants A and B is a phosphorescent compound.

4. The organic electroluminescent element of claim 1, wherein a thickness of the intermediate layer is larger than a Förster distance between light emission dopant A and light emission dopant B.

5. The organic electroluminescent element of claim 1 comprising at least one type of light emission layers comprising two or more layers of the same type showing the same light emission peak.

6. The organic electroluminescent element of claim 1 comprising at least two types of light emission layers, each type comprising two or more layers of the same type showing the same light emission peak.

7. The organic electroluminescent element of claim 1 comprising at least two types of light emission layers A and B, wherein
light emission layer A or light emission layer B comprises two or more layers; and
light emission layer A, light emission layer B and the intermediate layer are laminated alternately.

8. The organic electroluminescent element of claim 1 comprising at least three types of light emission layers A, B and C, wherein
at least one of light emission layers A, B and C comprises two or more layers; and
the light emission layers A, B and C are laminated periodically.

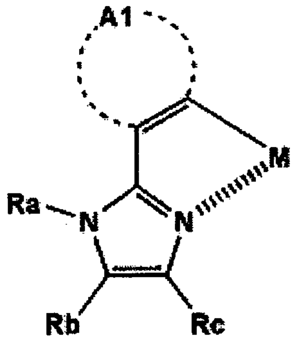
9. The organic electroluminescent element of claim 1, wherein
the organic electroluminescent element comprises a hole blocking layer provided between the light emission layer and the cathode; and
at least one of the hole blocking layer is provided adjacent to the light emission layer.

10. The organic electroluminescent element of claim 1, wherein
the organic electroluminescent element comprises an electron blocking layer provided between the light emission layer and the anode; and
at least one of the electron blocking layer is provided adjacent to the light emission layer.

11. The organic electroluminescent element of claim 1 emitting white light.

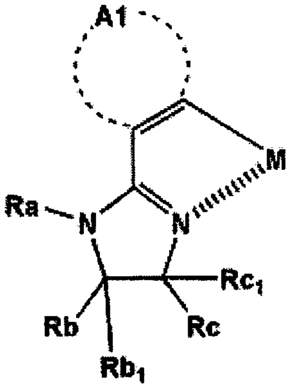
12. The organic electroluminescent element of claim 1, wherein the light emission layers comprise a light emission dopant having at least one of substructures represented by Formulas (A) to (C).

Formula (A)



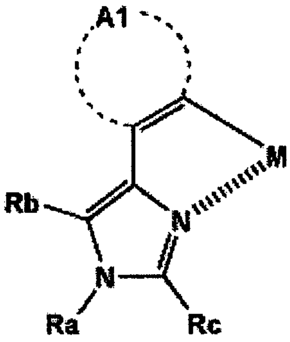
wherein, Ra is a hydrogen atom, an aliphatic group, an aromatic group or a heterocyclic group, Rb and Rc each are a hydrogen atom or a substituent, A1 is a residue necessary to form an aromatic ring or an aromatic heterocyclic ring and M is Ir or Pt;

Formula (B)



wherein Ra is a hydrogen atom, an aliphatic group, an aromatic group or a heterocyclic group, Rb, Rc, Rb1 and Rc1 each are a hydrogen atom or a substituent, A1 is a residue necessary to form an aromatic ring or an aromatic heterocyclic ring and M is Ir or Pt;

Formula (C)



wherein Ra is a hydrogen tom, an aliphatic group, an aromatic group or a heterocyclic group, Rb and Rc each are a hydrogen atom or a substituent, A1 is a residue necessary to form an aromatic ring or an aromatic heterocyclic ring and M is Ir or Pt.

13. A display comprising the organic electroluminescent element of claim 1.

14. An illuminator comprising the organic electroluminescent element of claim 1.

Patentansprüche

1. Organisches Elektrolumineszenzelement, umfassend eine Anode; eine Kathode; mindestens zwei Lichtemissionsschichten, die zwischen der Anode und der Kathode angebracht sind; und mindestens eine Zwischenschicht, die zwischen den zwei Lichtemissionsschichten angebracht ist, wobei die zwei Lichtemissionsschichten jeweils die gleiche Wirtsverbindung A umfassen;
eine der zwei Lichtemissionsschichten einen Lichtemissionsdotierungsstoff A umfasst und die andere Lichtemissionsschicht einen Lichtemissionsdotierungsstoff B, der von dem Lichtemissionsdotierungsstoff A verschieden ist, umfasst; und
die Zwischenschicht die Wirtsverbindung A umfasst, wobei die Wirtsverbindung A ein Carbazolderivat ist.

2. Organisches Elektrolumineszenzelement nach Anspruch 1, wobei mindestens einer der Dotierungsstoffe A und B eine phosphoreszierende Verbindung ist.

3. Organisches Elektrolumineszenzelement nach Anspruch 1, wobei jeder der Dotierungsstoffe A und B eine phosphoreszierende Verbindung ist.

4. Organisches Elektrolumineszenzelement nach Anspruch 1, wobei die Dicke der Zwischenschicht größer als der Förster-Abstand zwischen dem Lichtemissionsdotierungsstoff A und dem Lichtemissionsdotierungsstoff B ist.

5. Organisches Elektrolumineszenzelement nach Anspruch 1, das mindestens eine Art von Lichtemissionsschichten umfasst, die zwei oder mehr Schichten der gleichen Art, die den gleichen Lichtemissionspeak zeigen, umfasst.

6. Organisches Elektrolumineszenzelement nach Anspruch 1, das mindestens zwei Arten von Lichtemissionsschichten umfasst, wobei jede Art zwei oder mehr Schichten der gleichen Art, die den gleichen Lichtemissionspeak zeigen, umfasst.

7. Organisches Elektrolumineszenzelement nach Anspruch 1, das mindestens zwei Arten von Lichtemissionsschichten A und B umfasst, wobei
die Lichtemissionsschicht A oder die Lichtemissionsschicht B zwei oder mehr Schichten umfasst; und
die Lichtemissionsschicht A, die Lichtemissionsschicht B und die Zwischenschicht abwechselnd aufeinander geschichtet sind.

8. Organisches Elektrolumineszenzelement nach Anspruch 1, das mindestens drei Arten von Lichtemissionschichten A, B und C umfasst, wobei
mindestens eine der Lichtemissionschichten A, B und C zwei oder mehr Schichten umfasst; und
die Lichtemissionsschichten A, B und C periodisch aufeinander geschichtet sind.

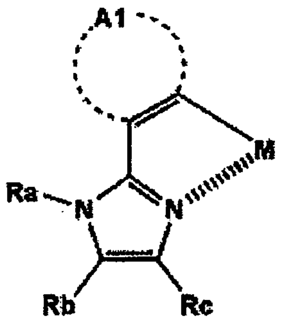
9. Organisches Elektrolumineszenzelement nach Anspruch 1, wobei
das organische Elektrolumineszenzelement eine Löcherblockierungsschicht umfasst, die zwischen der Lichtemissionsschicht und der Kathode angeordnet ist; und mindestens eine der Löcherblockierungsschichten angrenzend an die Lichtemissionsschicht angebracht ist.

10. Organisches Elektrolumineszenzelement nach Anspruch 1, wobei
das organische Elektrolumineszenzelement eine Elektronenblockierungsschicht umfasst, die zwischen der Lichtemissionsschicht und der Anode angeordnet ist; und mindestens eine der Elektronenblockierungsschichten angrenzend an die Lichtemissionsschicht angebracht ist.

11. Organisches Elektrolumineszenzelement nach Anspruch 1, das weißes Licht emittiert.

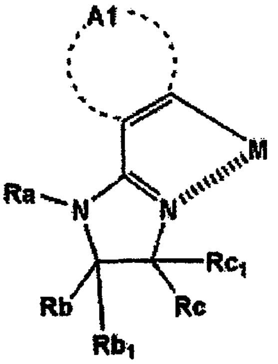
12. Organisches Elektrolumineszenzelement nach Anspruch 1, wobei die Lichtemissionsschichten einen Lichtemissionsdotierungsstoff umfassen, der mindestens eine der durch die Formeln (A) bis (C) dargestellten Teilstrukturen aufweist.

Formel (A)



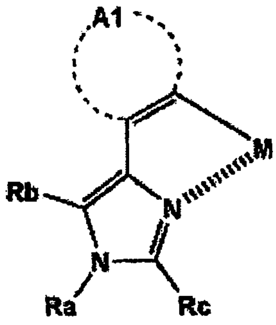
worin
Ra für ein Wasserstoffatom, eine aliphatische Gruppe, eine aromatische Gruppe oder eine heterocyclische Gruppe steht, Rb und Rc jeweils für ein Wasserstoffatom oder einen Substituenten stehen,
Al für einen zur Bildung eines aromatischen Rings oder eines aromatischen heterocyclischen Rings notwendigen Rest steht und
M für Ir oder Pt steht;

Formel (B)



worin
Ra für ein Wasserstoffatom, eine aliphatische Gruppe, eine aromatische Gruppe oder eine heterocyclische Gruppe steht, Rb, Rc, Rb1 und Rcl jeweils für ein Wasserstoffatom oder einen Substituenten stehen,
A1 für einen zur Bildung eines aromatischen Rings oder eines aromatischen heterocyclischen Rings notwendigen Rest steht und
M für Ir oder Pt steht;

Formel (C)



worin
Ra für ein Wasserstoffatom, eine aliphatische Gruppe, eine aromatische Gruppe oder eine heterocyclische Gruppe steht, Rb und Rc jeweils für ein Wasserstoffatom oder einen Substituenten stehen,
A1 für einen zur Bildung eines aromatischen Rings oder eines aromatischen heterocyclischen Rings notwendigen Rest steht und
M für Ir oder Pt steht.

13. Anzeigevorrichtung, die das organische Elektrolumineszenzelement nach Anspruch 1 umfasst.

14. Beleuchtungsvorrichtung, die das organische Elektrolumineszenzelement nach Anspruch 1 umfasst.

Revendications

1. Élément électroluminescent organique comprenant une anode ; une cathode ; au moins deux couches d'émission de lumière disposées entre l'anode et la cathode ; et au moins une couche intermédiaire disposée entre les deux couches d'émission de lumière, dans lequel
les deux couches d'émission de lumière comprennent chacune le même composé hôte A ;
l'une des deux couches d'émission de lumière comprend un dopant d'émission de lumière A et l'autre couche d'émission de lumière comprend un dopant d'émission de lumière B qui est différent du dopant d'émission de lumière A ;
et
la couche intermédiaire comprend le composé hôte A, le composé hôte A étant un dérivé du carbazole.

2. Élément électroluminescent organique selon la revendication 1, dans lequel au moins l'un des dopants A et B est un composé phosphorescent.

3. Élément électroluminescent organique selon la revendication 1, dans lequel
chacun des dopants A et B est un composé phosphorescent.

4. Élément électroluminescent organique selon la revendication 1, dans lequel l'épaisseur de la couche intermédiaire est supérieure à la distance de Förster entre le dopant d'émission de lumière A et le dopant d'émission de lumière B.

5. Élément électroluminescent organique selon la revendication 1 comprenant au moins un type de couches d'émission de lumière comprenant deux ou plusieurs couches du même type montrant le même pic d'émission de lumière.

6. Élément électroluminescent organique selon la revendication 1 comprenant au moins deux types de couches d'émission de lumière, chaque type comprenant deux ou plusieurs couches du même type montrant le même pic d'émission de lumière.

7. Élément électroluminescent organique selon la revendication 1 comprenant au moins deux types de couches d'émission de lumière A et B, dans lequel
la couche d'émission de lumière A ou la couche d'émission de lumière B comprend deux ou plusieurs couches ; et la couche d'émission de lumière A, la couche d'émission de lumière B et la couche intermédiaire sont stratifiées en

alternance.

8. Élément électroluminescent organique selon la revendication 1 comprenant au moins trois types de couches d'émission de lumière A, B et C, dans lequel
au moins l'une des couches d'émission de lumière A, B et C comprend deux ou plusieurs couches ; et
les couches d'émission de lumière A, B et C sont stratifiées de façon périodique.

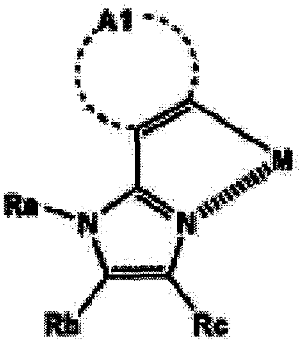
9. Élément électroluminescent organique selon la revendication 1, dans lequel
l'élément électroluminescent organique comprend une couche de blocage de trous disposée entre la couche d'émission de lumière et la cathode ; et
au moins l'une des couches de blocage de trous est disposée adjacente à la couche d'émission de lumière.

10. Élément électroluminescent organique selon la revendication 1, dans lequel
l'élément électroluminescent organique comprend une couche de blocage d'électrons disposée entre la couche d'émission de lumière et l'anode ; et
au moins l'une des couches de blocage d'électrons est disposée adjacente à la couche d'émission de lumière.

11. Élément électroluminescent organique selon la revendication 1 émettant une lumière blanche.

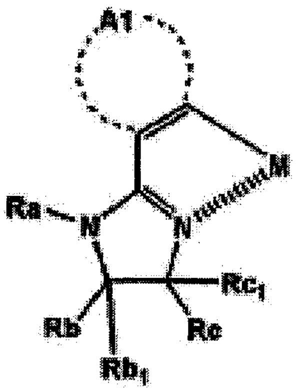
12. Élément électroluminescent organique selon la revendication 1, dans lequel les couches d'émission de lumière comprennent un dopant d'émission de lumière ayant au moins l'une des sous-structures représentées par les Formules (A) à (C).

Formule (A)



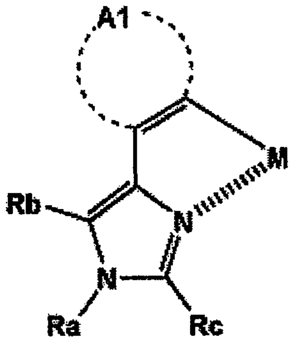
dans laquelle Ra représente un atome d'hydrogène, un groupe aliphatique, un groupe aromatique ou un groupe hétérocyclique, Rb et Rc représentent chacun un atome d'hydrogène ou un substituant, Al représente un résidu nécessaire pour former un cycle aromatique ou un hétérocycle aromatique et M représente un atome d'Ir ou de Pt ;

Formule (B)



dans laquelle Ra représente un atome d'hydrogène, un groupe aliphatique, un groupe aromatique ou un groupe hétérocyclique, Rb, Rc, Rb1 et Rc1 représentent chacun un atome d'hydrogène ou un substituant, Al représente un résidu nécessaire pour former un cycle aromatique ou un hétérocycle aromatique et M représente un atome d'Ir ou de Pt ;

Formule (C)



dans laquelle Ra représente un atome d'hydrogène, un groupe aliphatique, un groupe aromatique ou un groupe hétérocyclique, Rb et Rc représentent chacun un atome d'hydrogène ou un substituant, Al représente un résidu nécessaire pour former un cycle aromatique ou un hétérocycle aromatique et M représente un atome d'Ir ou de Pt.

13. Écran comprenant l'élément électroluminescent organique selon la revendication 1.

14. Illuminateur comprenant l'élément électroluminescent organique selon la revendication 1.

FIG. 1

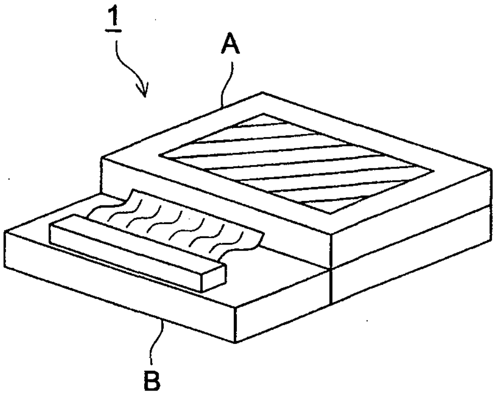


FIG. 2

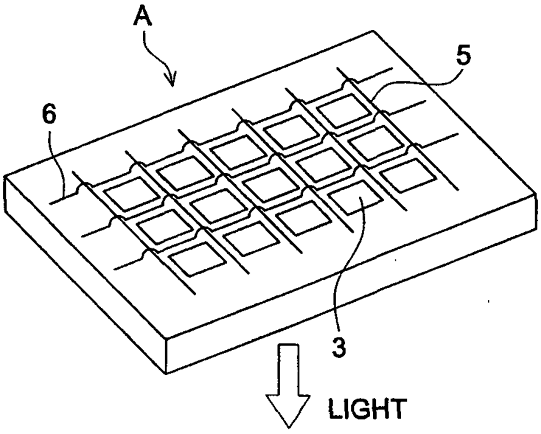


FIG. 3

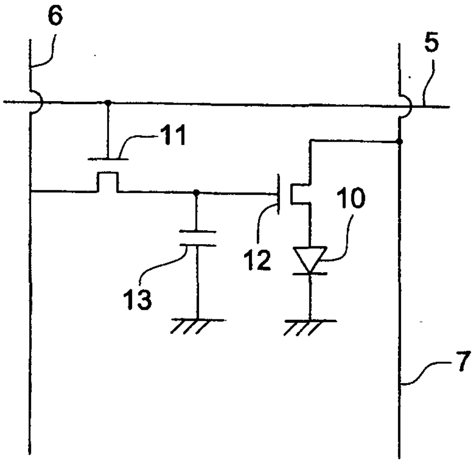


FIG. 4

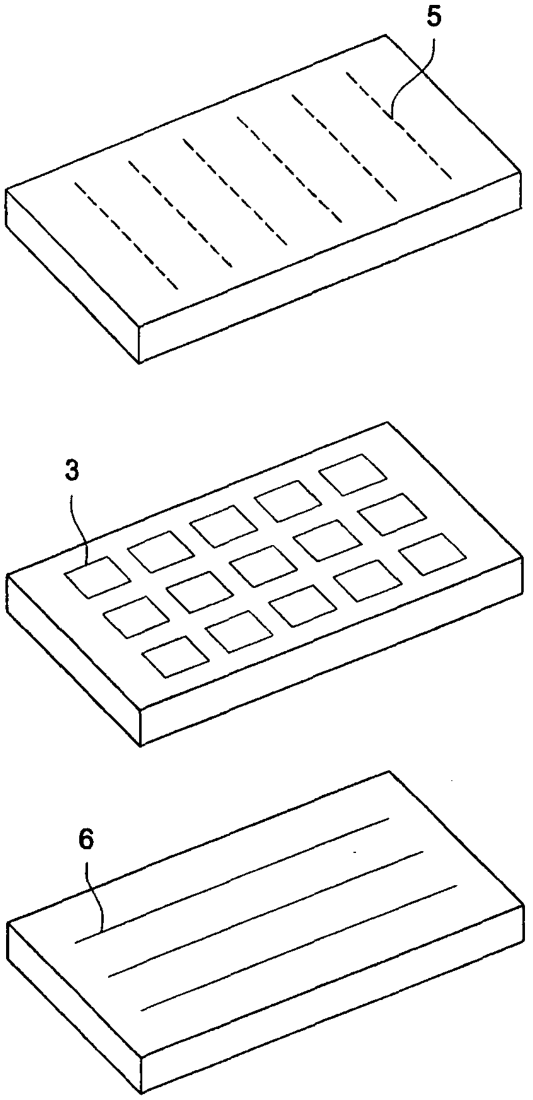


FIG. 5

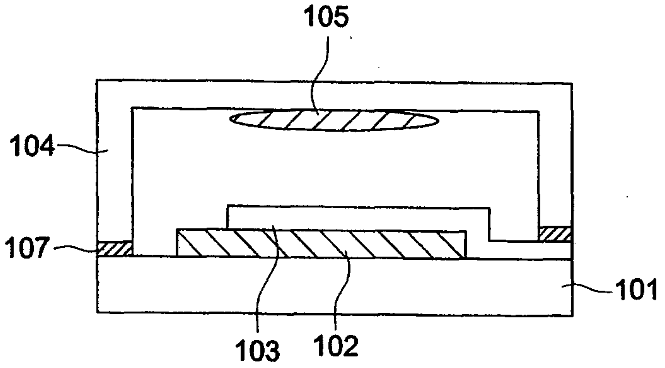


FIG. 6 (a)

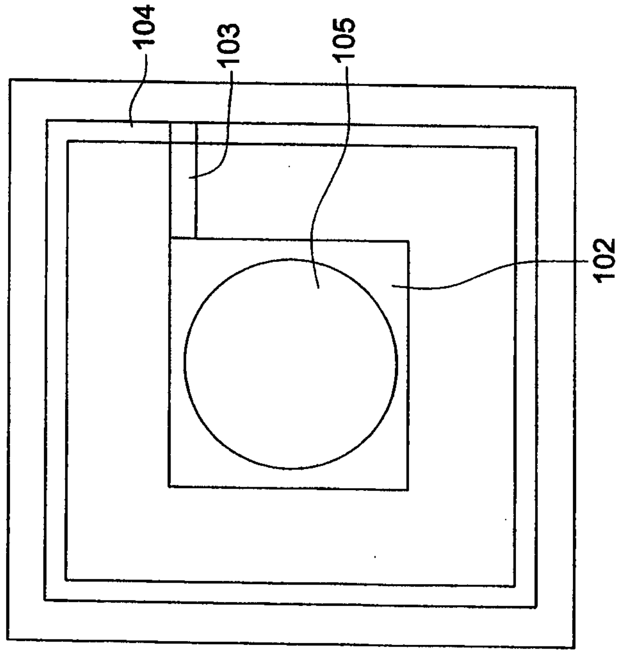


FIG. 6 (b)

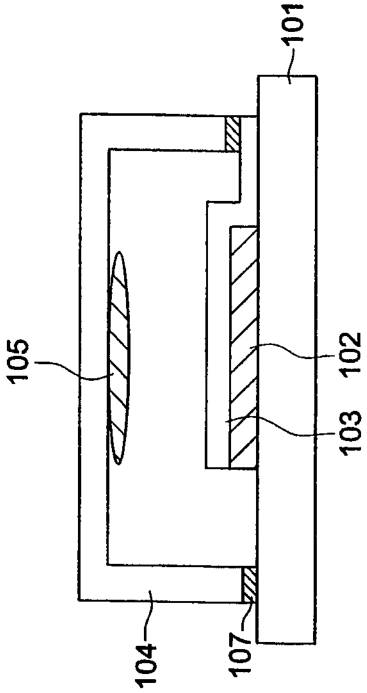


FIG. 7

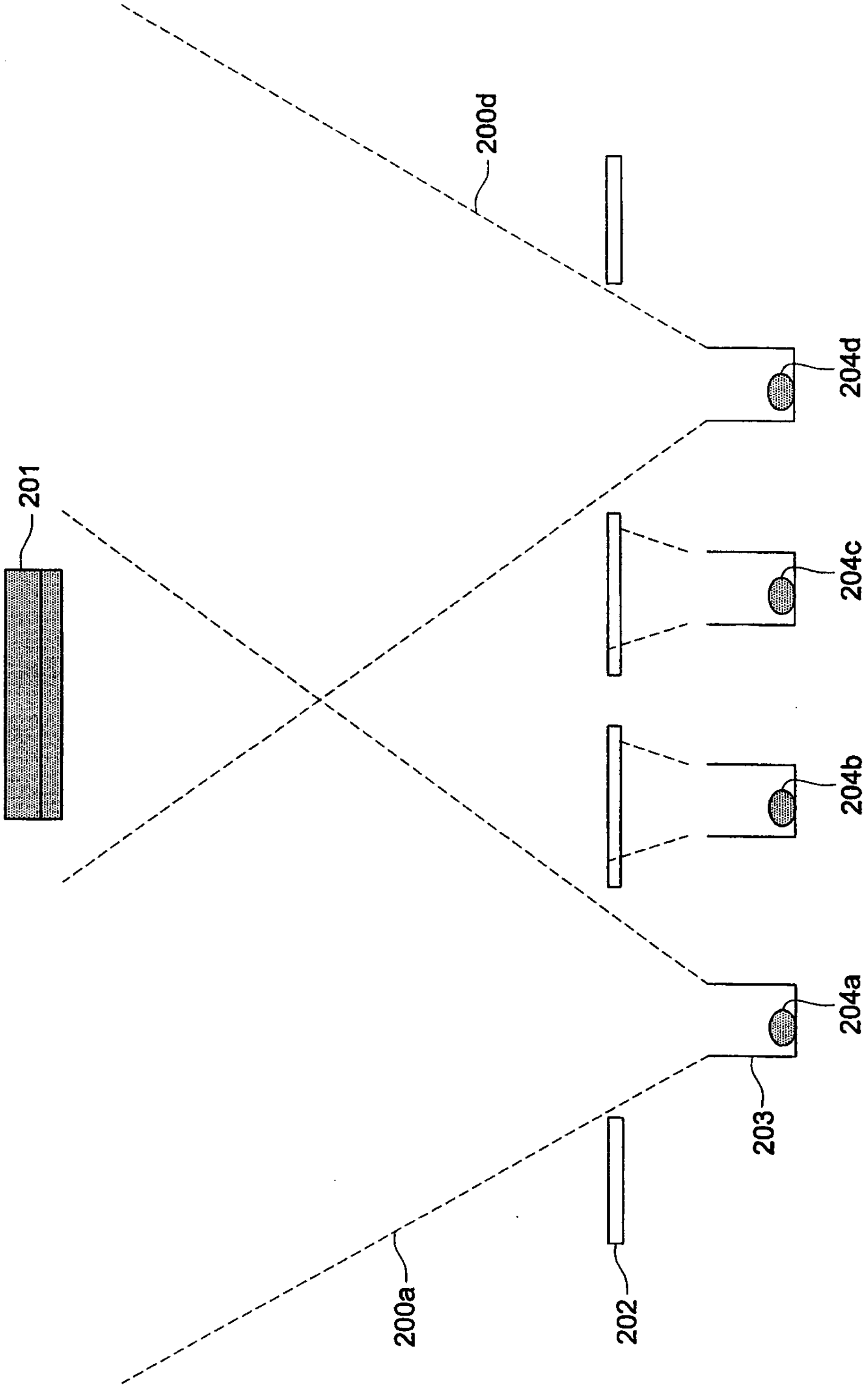


FIG. 8

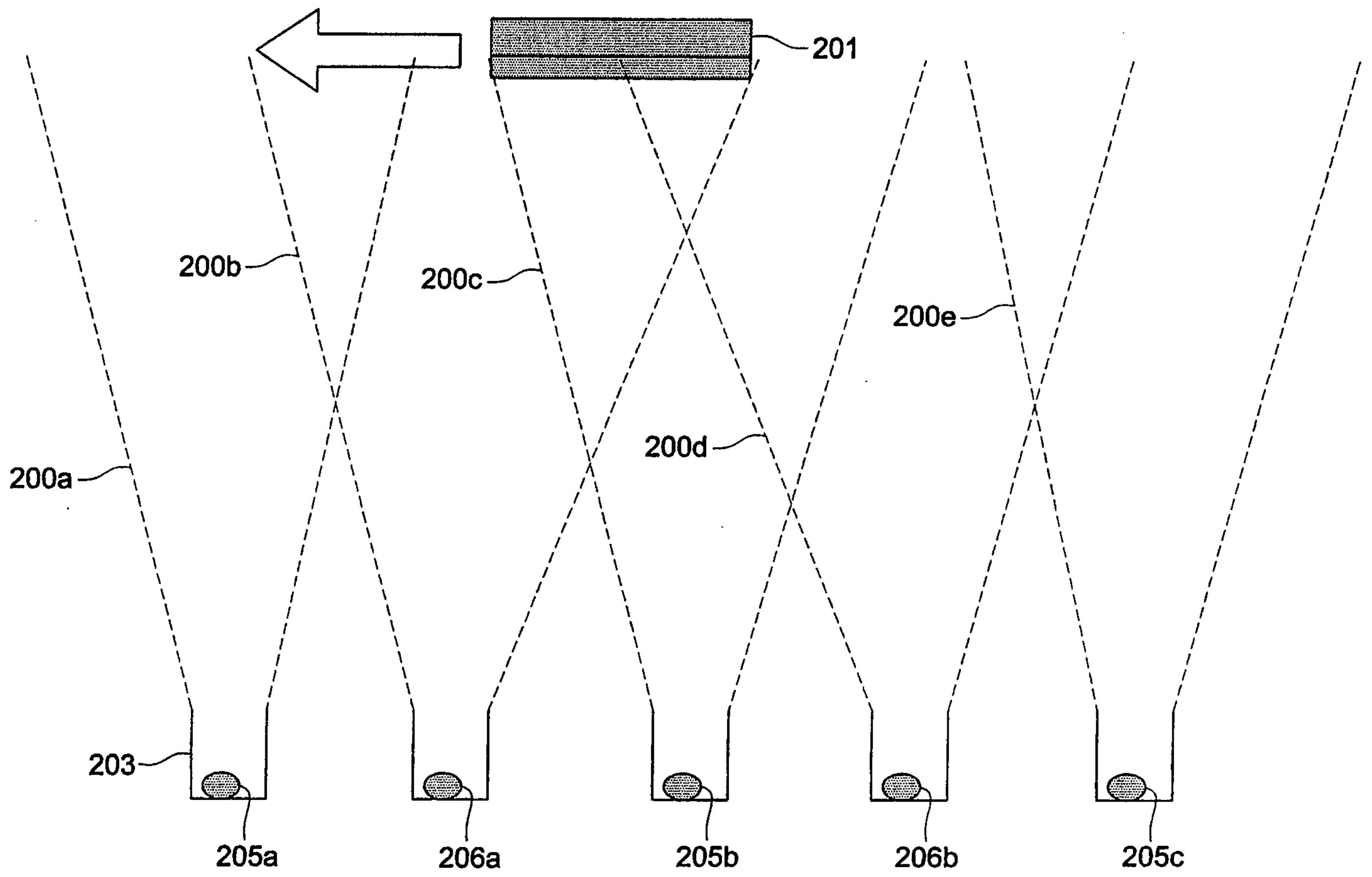
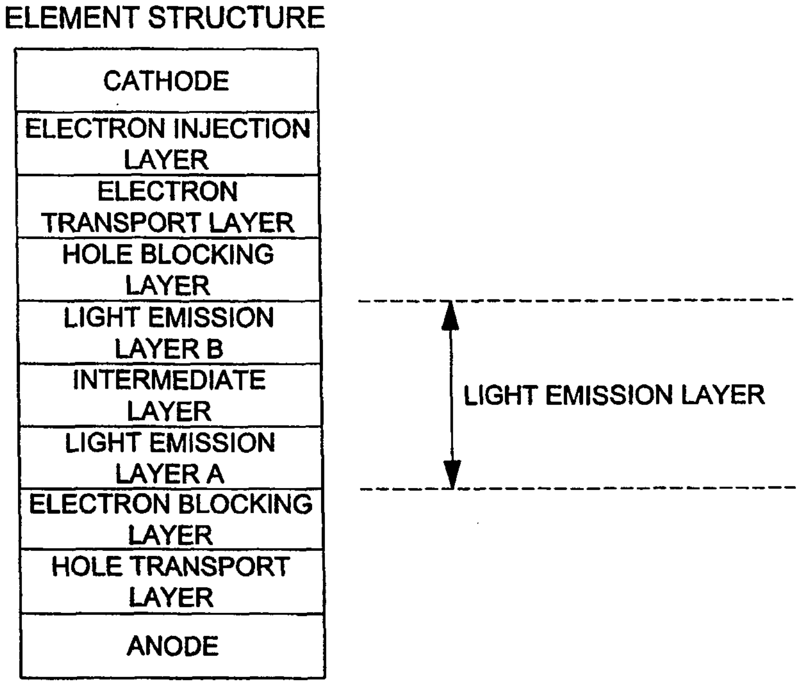


FIG. 9



ELEMENT STRUCTURE 1

FIG. 10

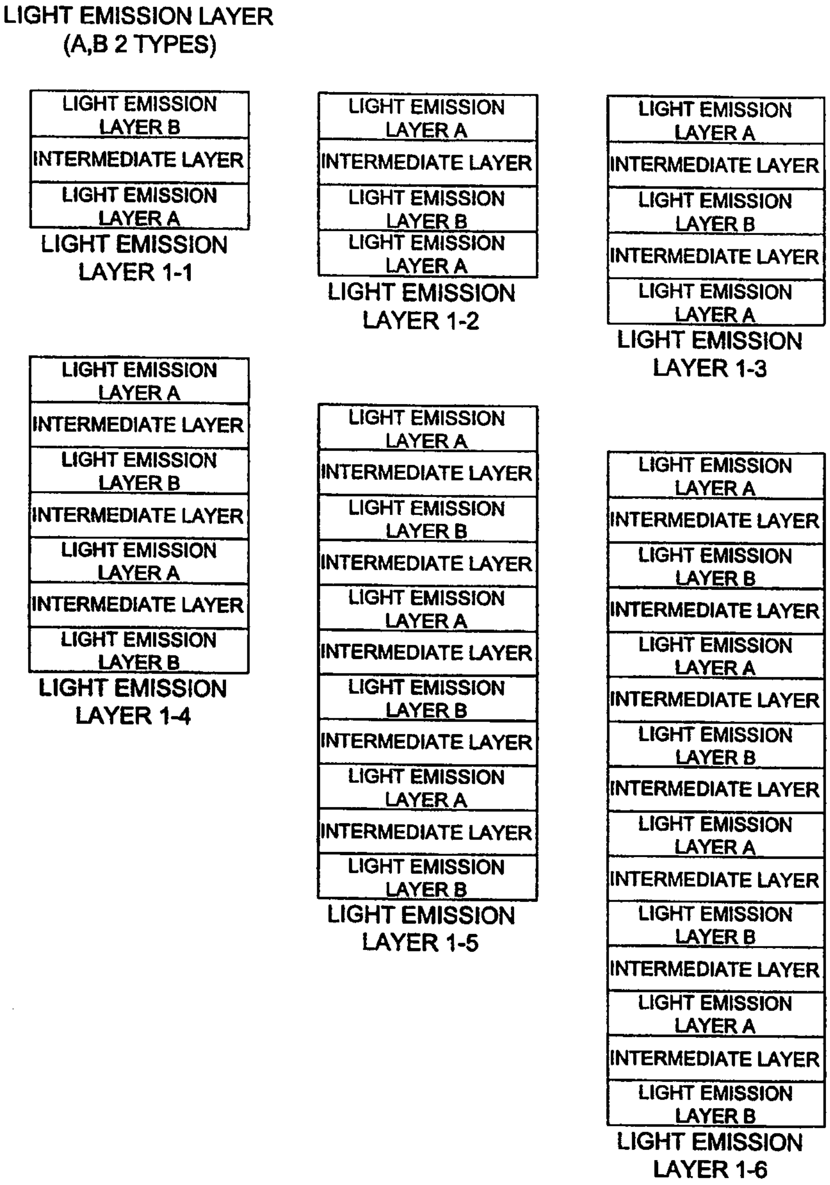

LIGHT EMISSION LAYER (A,B 2 TYPES)
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER A
LIGHT EMISSION LAYER 1-1
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
LIGHT EMISSION LAYER A
LIGHT EMISSION LAYER 1-2
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER A
LIGHT EMISSION LAYER 1-3
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
LIGHT EMISSION LAYER 1-4
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
LIGHT EMISSION LAYER 1-5
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
LIGHT EMISSION LAYER 1-6

FIG. 11

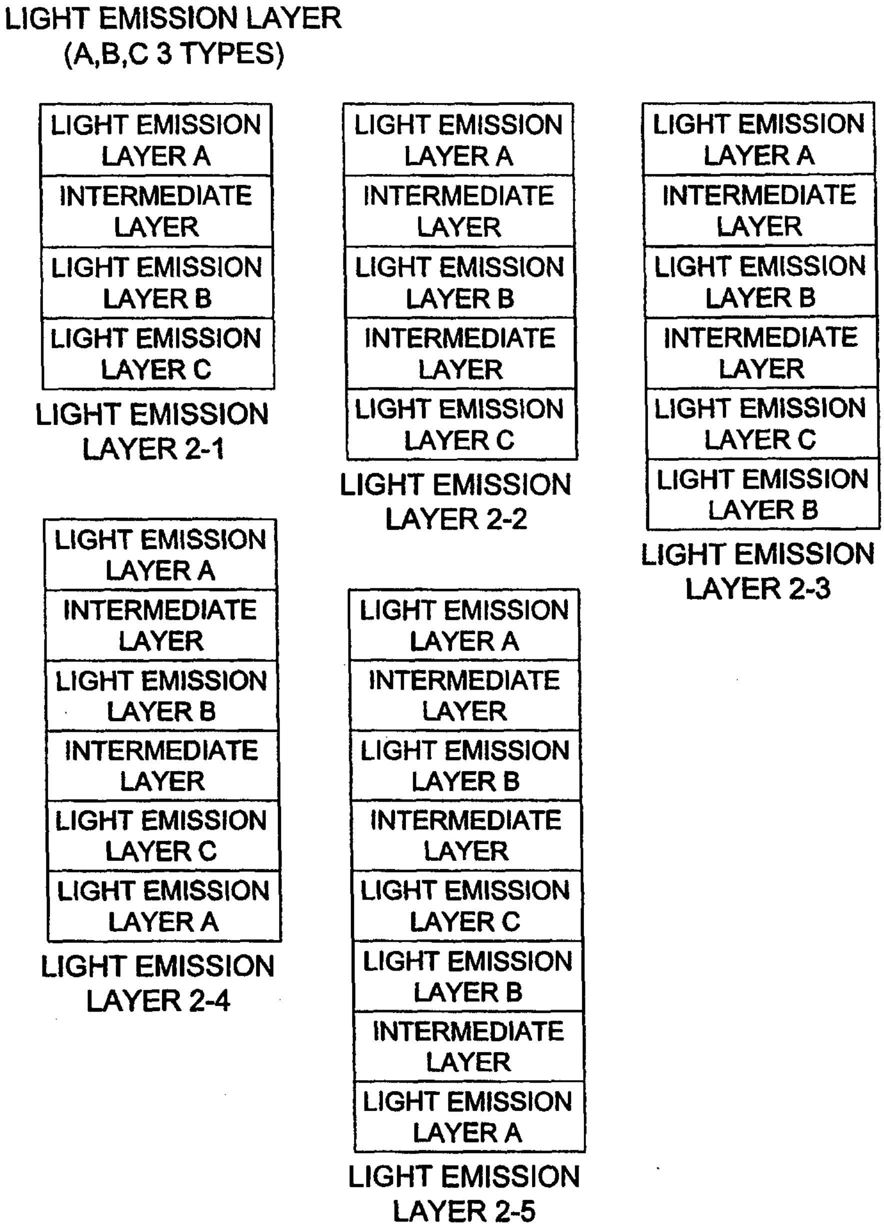

LIGHT EMISSION LAYER
(A,B,C 3 TYPES)
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
LIGHT EMISSION LAYER C
LIGHT EMISSION LAYER 2-1
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER C
LIGHT EMISSION LAYER 2-2
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER C
LIGHT EMISSION LAYER B
LIGHT EMISSION LAYER 2-3
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER C
LIGHT EMISSION LAYER A
LIGHT EMISSION LAYER 2-4
LIGHT EMISSION LAYER A
INTERMEDIATE LAYER
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER C
LIGHT EMISSION LAYER B
INTERMEDIATE LAYER
LIGHT EMISSION LAYER A
LIGHT EMISSION LAYER 2-5

FIG. 12

LIGHT EMISSION LAYER 2-6

LIGHT EMISSION LAYER 2-9

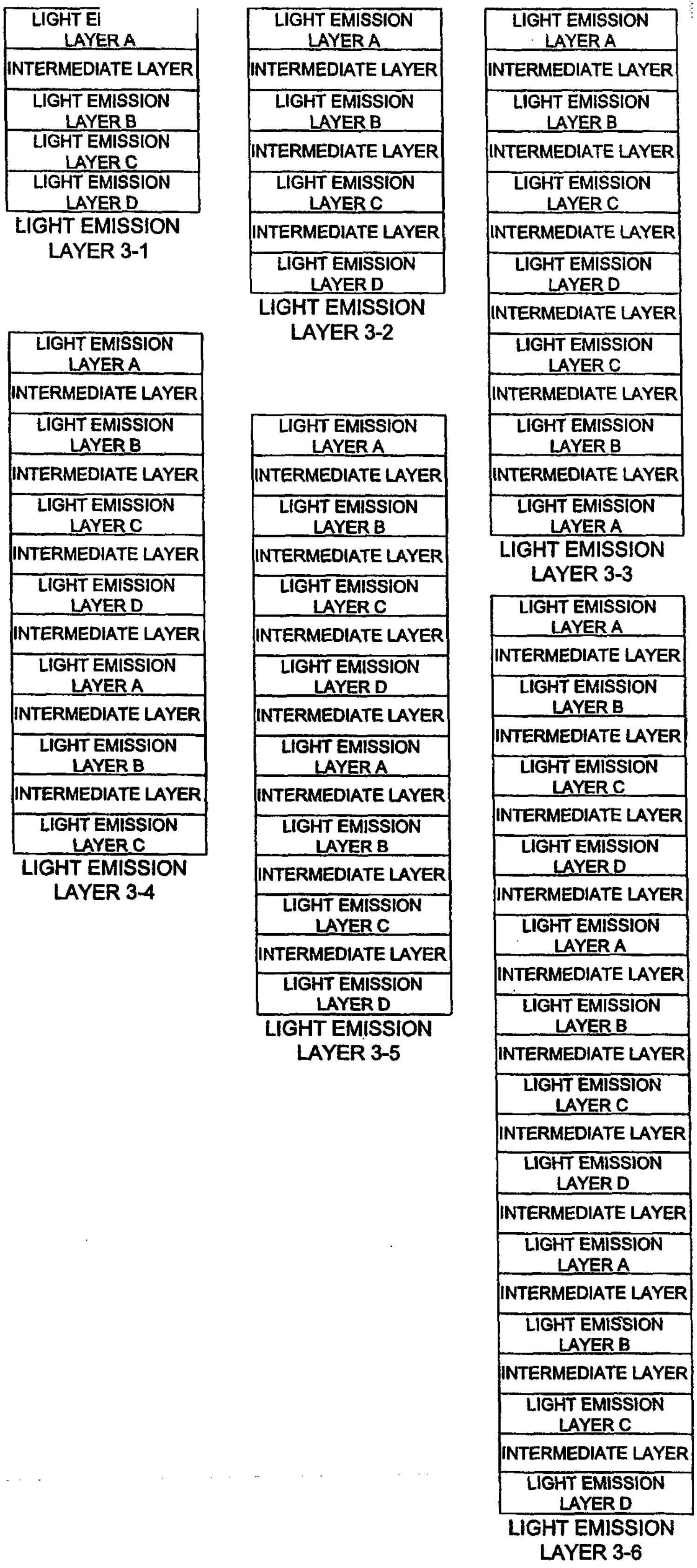
LIGHT EMISSION LAYER 2-7

LIGHT EMISSION LAYER 2-10

LIGHT EMISSION LAYER 2-8

FIG. 13

LIGHT EMISSION LAYER
(A,B,C,D 4 TYPES)



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专利名称(译)	有机电致发光元件，显示器和发光器		
公开(公告)号	EP2178348B1	公开(公告)日	2012-11-21
申请号	EP2010152814	申请日	2005-07-13
[标]申请(专利权)人(译)	柯尼卡株式会社		
申请(专利权)人(译)	柯尼卡美能达控股株式会社.		
当前申请(专利权)人(译)	柯尼卡美能达控股株式会社.		
[标]发明人	SUZURI YOSHIYUKI KITA HIROSHI		
发明人	SUZURI, YOSHIYUKI KITA, HIROSHI		
IPC分类号	C09K11/06 H01L51/50		
CPC分类号	C09K11/06 C09K2211/1029 C09K2211/1044 C09K2211/1048 C09K2211/1092 C09K2211/185 H01L51/5016 H01L51/5036 H05B33/14		
优先权	2004215728 2004-07-23 JP		
其他公开文献	EP2178348A2 EP2178348A3		
外部链接	Espacenet		

摘要(译)

一种有机电致发光元件，包括阳极;阴极;在阳极和阴极之间提供至少两个发光层;在两个发光层之间设置至少一个中间层，其中两个发光层各自包含相同的主体化合物A;两个发光层中的一个包括发光掺杂剂A，另一个发光层包括与发光掺杂剂A不同的发光掺杂剂B;中间层包含主体化合物A.

Formula (A)