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(54) SOLUTION PROCESSABLE DOPED TRIARYLAMINE HOLE INJECTION MATERIALS

LÖSUNGSVERARBEITBARE DOTIERTE TRIARYLAMINLOCHINJEKTIONSMATERIALIEN

SUBSTANCES D'INJECTION DE TROU TRIARYLAMINE DOPÉES POUVANT ÊTRE TRAITÉES EN SOLUTION

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EP 2 550 690 B1

Description

FIELD OF THE INVENTION (clean version)

[0001] The present invention relates to organic light emitting devices (OLEDs). More specifically, the present invention relates to methods for fabricating a device containing an organic layer comprising an organic electron donor and an organic electron acceptor that forms a layer insoluble to a non-polar solvent, and devices containing the organic layer.

BACKGROUND

[0002] Opto-electronic devices that make use of organic materials are becoming increasingly desirable for a number of reasons. Many of the materials used to make such devices are relatively inexpensive, so organic opto-electronic devices have the potential for cost advantages over inorganic devices. In addition, the inherent properties of organic materials, such as their flexibility, may make them well suited for particular applications such as fabrication on a flexible substrate. Examples of organic opto-electronic devices include organic light emitting devices (OLEDs), organic phototransistors, organic photovoltaic cells, and organic photodetectors. For OLEDs, the organic materials may have performance advantages over conventional materials. For example, the wavelength at which an organic emissive layer emits light may generally be readily tuned with appropriate dopants.

[0003] OLEDs make use of thin organic films that emit light when voltage is applied across the device. OLEDs are becoming an increasingly interesting technology for use in applications such as flat panel displays, illumination, and backlighting. Several OLED materials and configurations are described in U.S. Pat. Nos. 5,844,363, 6,303,238, and 5,707,745.

[0004] OLEDs and a process for preparing the same are described in International Patent Application Publication No. WO 2007/105906.

[0005] The stability of organic light-emitting devices with a spin-coated film of 4,4',4"-tris(3-methylphenylphenylamino)triphenylamine (m-MTDATA) as hole-injection layer (HIL) was investigated by Zhang et al., "Improving the stability of organic light-emitting devices using a solution-processed hole-injecting layer", APPLIED SURFACE SCIENCE, (20090506), vol. 255, pages 7970 - 7973.

[0006] A material for an organic electroluminescence device is described in US 2010/044686.

[0007] A high-efficiency organic EL device that can be fabricated by a simple process and that can prevent color shift arising from variations in film thickness is described in US 2008/224595.

[0008] Organic n doped electron transport layers comprising at least one electron transport material and at least one electron rich dopant material and organic p-doped hole transport layers comprising at least one hole transport material and at least one electron deficient dopant material are described in US 2007/181874.

[0009] An organic EL element which comprises at least a luminescent layer, a hole transport layer adjacent to a positive-electrode side of the luminescent layer, and an electron injection transport layer adjacent to a negative-electrode side of the luminescent layer, wherein a hole injection layer is provided between the hole transport layer and the positive electrode, and the conductivity of the hole injection layer continuously changes along a thickness direction of the hole injection layer is described in US 2008/038583.

[0010] An electroluminescent device with an anode, a cathode, and an organic layer having at least a light-emitting layer and held between the anode and the cathode is described in US 2008/233387.

[0011] Amine compounds, their preparation processes and the organic electroluminescent devices using the same are described in US 2008/038587.

[0012] An organic light emitting device including a substrate; a first electrode; a second electrode; and an organic layer interposed between the first electrode and the second electrode and including an emission layer, wherein one of the first electrode and the second electrode is a reflective electrode and the other is a semitransparent or transparent electrode, and wherein the organic layer includes a layer having at least one of the compounds having at least one carbazole group, and a flat panel display device including the organic light emitting device is described in EP 1 862 524 A1.

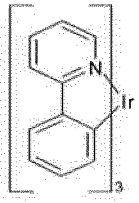
[0013] A manufacturing method of an organic electroluminescent element of long life and high luminous efficiency is described in JP 2008 198365 A.

[0014] A way to fabricate a phosphorescent OLED using 4,4',4"-tris(N-carbazolyl)-triphenylamine (TCTA) small molecule interlayer by solution process is described by Park et al., "Small molecule interlayer for solution processed phosphorescent organic light emitting device", Organic Electronics, vol. 10, 2009, 189-193.

[0015] One application for phosphorescent emissive molecules is a full color display. Industry standards for such a display call for pixels adapted to emit particular colors, referred to as "saturated" colors. In particular, these standards call for saturated red, green, and blue pixels. Color may be measured using CIE coordinates, which are well known to the art.

[0016] One example of a green emissive molecule is tris(2-phenylpyridine) iridium, denoted $Ir(ppy)_3$, which has the

structure:



[0017] In this, and later figures herein, we depict the dative bond from nitrogen to metal (here, Ir) as a straight line.

[0018] As used herein, the term "organic" includes polymeric materials as well as small molecule organic materials that may be used to fabricate organic opto-electronic devices. "Small molecule" refers to any organic material that is not a polymer, and "small molecules" may actually be quite large. Small molecules may include repeat units in some circumstances. For example, using a long chain alkyl group as a substituent does not remove a molecule from the "small molecule" class. Small molecules may also be incorporated into polymers, for example as a pendent group on a polymer backbone or as a part of the backbone. Small molecules may also serve as the core moiety of a dendrimer, which consists of a series of chemical shells built on the core moiety. The core moiety of a dendrimer may be a fluorescent or phosphorescent small molecule emitter. A dendrimer may be a "small molecule," and it is believed that all dendrimers currently used in the field of OLEDs are small molecules.

[0019] As used herein, "top" means furthest away from the substrate, while "bottom" means closest to the substrate. Where a first layer is described as "disposed over" a second layer, the first layer is disposed further away from substrate. There may be other layers between the first and second layer, unless it is specified that the first layer is "in contact with" the second layer. For example, a cathode may be described as "disposed over" an anode, even though there are various organic layers in between.

[0020] As used herein, "solution processible" means capable of being dissolved, dispersed, or transported in and/or deposited from a liquid medium, either in solution or suspension form.

[0021] A ligand may be referred to as "photoactive" when it is believed that the ligand directly contributes to the photoactive properties of an emissive material. A ligand may be referred to as "ancillary" when it is believed that the ligand does not contribute to the photoactive properties of an emissive material, although an ancillary ligand may alter the properties of a photoactive ligand.

[0022] As used herein, and as would be generally understood by one skilled in the art, a first "Highest Occupied Molecular Orbital" (HOMO) or "Lowest Unoccupied Molecular Orbital" (LUMO) energy level is "greater than" or "higher than" a second HOMO or LUMO energy level if the first energy level is closer to the vacuum energy level. Since ionization potentials (IP) are measured as a negative energy relative to a vacuum level, a higher HOMO energy level corresponds to an IP having a smaller absolute value (an IP that is less negative). Similarly, a higher LUMO energy level corresponds to an electron affinity (EA) having a smaller absolute value (an EA that is less negative). On a conventional energy level diagram, with the vacuum level at the top, the LUMO energy level of a material is higher than the HOMO energy level of the same material. A "higher" HOMO or LUMO energy level appears closer to the top of such a diagram than a "lower" HOMO or LUMO energy level.

[0023] As used herein, and as would be generally understood by one skilled in the art, a first work function is "greater than" or "higher than" a second work function if the first work function has a higher absolute value. Because work functions are generally measured as negative numbers relative to vacuum level, this means that a "higher" work function is more negative. On a conventional energy level diagram, with the vacuum level at the top, a "higher" work function is illustrated as further away from the vacuum level in the downward direction. Thus, the definitions of HOMO and LUMO energy levels follow a different convention than work functions.

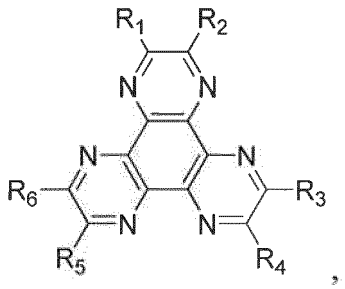
[0024] More details on OLEDs, and the definitions described above, can be found in US Pat. No. 7,279,704.

SUMMARY OF THE INVENTION

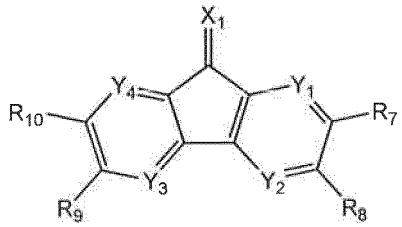
[0025] A method of fabricating an organic light emitting device according to claim 1 is provided. The method comprises providing an electrode, depositing a first organic layer in contact with the electrode by a solution process, and heating the first organic layer to form a layer that is insoluble in a non-polar solvent. Preferably, the electrode is an anode. The first organic layer is deposited in contact with the anode.

[0026] The first organic layer comprises a non-crosslinkable organic electron acceptor and a non-crosslinkable organic electron donor as defined in claim 1.

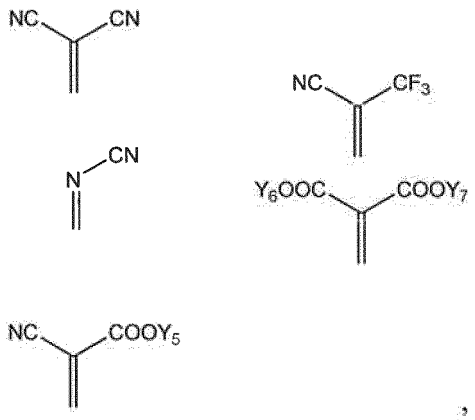
[0027] In one aspect, the non-crosslinkable organic electron acceptor is selected from the group consisting of:



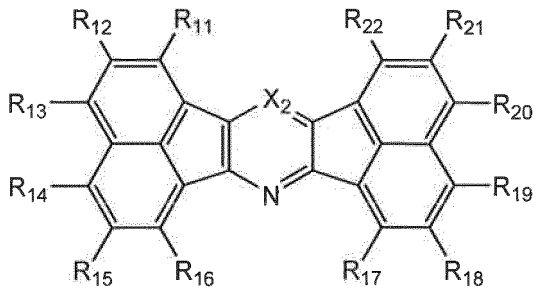
R_1, R_2, R_3, R_4, R_5, and R_6 are independently chosen from the group consisting of hydrogen, halogen, nitrile, nitro, sulfonyl, solfoxide, sulfonamide, sulfonate, trifluoromethyl, ester, amide, straight-chain or branched C1-C12 alkoxy, straight-chain or branched C1-C12 alkyl, aromatic or non-aromatic (substituted or unsubstituted) heterocyclic, substituted or unsubstituted aryl, mono- or di-(substituted or unsibstituted)aryl-amine, and (substituted or unsubstituted)alkyl-(substituted or unsubstituted)aryl-amine; or where R_1 and R_2, R_3 and R_4, and R_5 and R_6 combine form a ring structure including an aromatic ring, a heteroaromatic ring, or a non-aromatic ring, and each ring is substituted or unsubstituted;



Y_1 to Y_4 are independently a carbon atom or a nitrogen atom. R_7 to R_{10} are independently a hydrogen atom, an alkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted heterocycle, a halogen atom, a fluoroalkyl group or a cyano group. R_7 and R_8, and R_9 and R_{10} are independently bonded to form a substituted or unsubstituted aromatic ring or a substituted or unsubstituted heterocycle. X_1 is selected from the group consisting of:



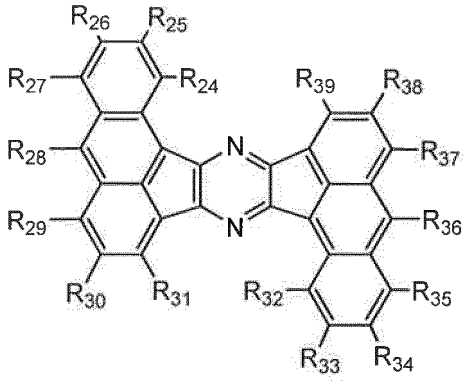
Y_5 to Y_7 are independently a hydrogen atom, a fluoroalkyl group, an alkyl group, an aryl group or a heterocyclic group; and Y_6 and Y_7 may form a ring;



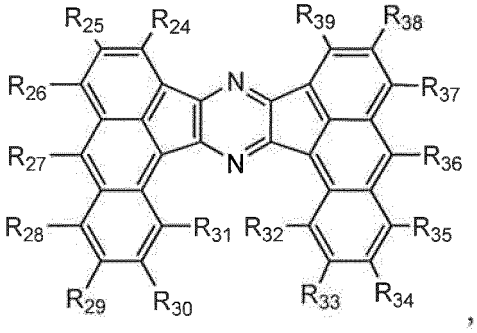
X_2 is

,

$C(R_{23})$ or N, R_{11} to R_{23} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{11} to R_{23} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{11} to R_{23}, which are adjacent to one another, may be linked together to form a ring structure;



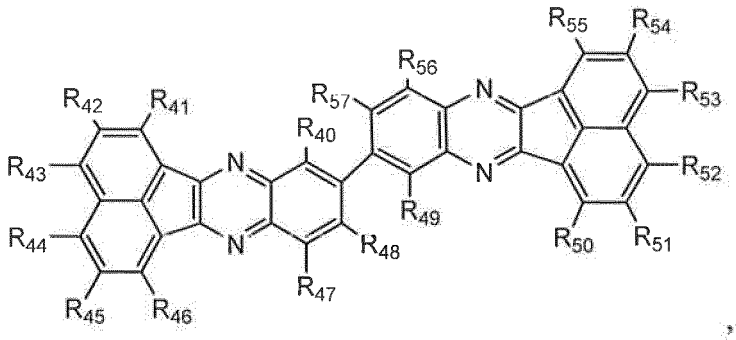
and



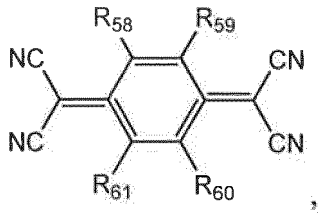
,

R_{24} to R_{39} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a

halogen atom, or a cyano group, provided that at least two of R_{24} to R_{39} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{24} to R_{39} which are adjacent to one another, may be linked together to form a ring structure;

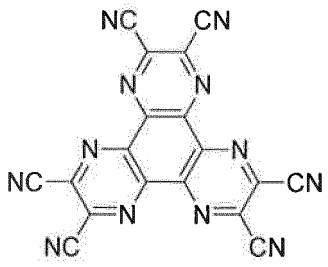


R_{40} to R_{57} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{40} to R_{57} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{40} to R_{57} which are adjacent to one another, may be linked together to form a ring structure; and



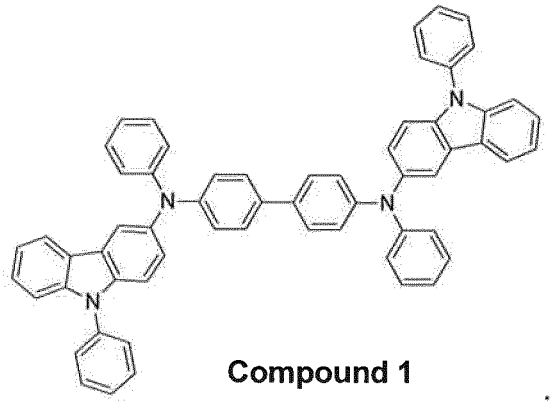
R_{58}-R_{61} independently represents hydrogen, fluorine,or substituents independently selected from nitrile (-CN), nitro (-NO_2), sulfonyl (-SO_2R), sulfoxide (-SOR), trifluoromethyl (-CF_3), ester (-CO-DR), amide (-CONHR or -CO-NRR'), substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or substituted or unsubstituted alkyl, where Rand R' include substituted or unsubstituted alkyl or aryl; or R_{58} and R_{59}, or R_{60} and R_{61}, combine form a ring structure including an aromatic ring, a heteroaromatic ring, or a non-aromatic ring, and each ring is substituted or unsubstituted.

[0028] Preferably, the non-crosslinkable organic electron acceptor is:



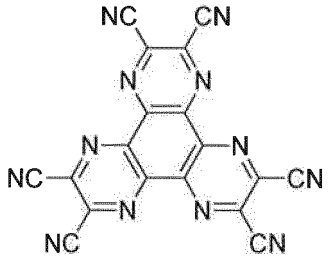
Dopant 1

[0029] Preferably, the non-crosslinkable organic electron donor is



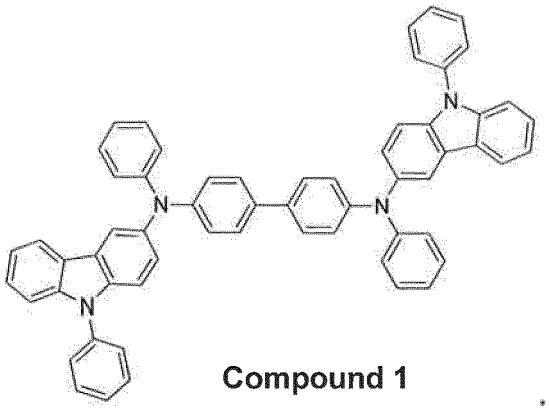
Compound 1

[0030] More preferably, the non-crosslinkable organic electron acceptor is:



Dopant 1

and
the non-crosslinkable organic electron donor is



Compound 1

[0031] In one aspect, a second organic layer containing a non-polar solvent is deposited over the first organic layer, and the first organic layer is insoluble to the non-polar solvent in the second organic layer. Preferably, the first organic layer is a hole injection layer. Preferably, the second organic layer is a hole transporting layer, a hole blocking layer, an electron transporting layer, an electron injection layer, or an emissive layer.

[0032] Non-polar solvents, as used herein, have a polarity index equal to or less than 3.5. In one aspect, the non-polar solvent is selected from the group consisting of benzene, carbon tetrachloride, cyclohexane, 1,2-dichloroethane, dichloromethane, di-ethyl ether, heptane, hexane, methyl-t-butyl ether, pentane, di-iso-propyl ether, toluene, and xylene. Preferably, the non-polar solvent is toluene.

[0033] In one aspect, the solution process is spin coating or inkjet printing.

[0034] In another aspect, the organic electron acceptor and the organic electron donor are mixed at a mole ratio of 1:1 or 2:1.

[0035] In yet another aspect, the insoluble organic layer forms when the composition is heated at a temperature no

less than about 100° C and no more than about 250° C.

[0036] Additionally, a first device is provided, the device comprising an organic light emitting device, which further comprises an anode; a cathode; and a first organic layer disposed between the anode and the cathode, in contact with the anode or the cathode, the organic layer comprising a non-crosslinkable electron acceptor and a non-crosslinkable electron donor. Selections for the substituents, solvents, organic electron acceptor and organic electron donor mole ratio, and temperature described as preferred for the method are also preferred for use in a device that comprises an organic layer comprising the electron acceptor and the electron donor. These selections include those described at least for A, B, C, R_Λ, R_B, R_C, X, Y, R_X, R_Y, R_1-R_{61}, Y_1-Y_7, X_1, X_2, R'_1-R'_{13}, Λr_1-Λr_4, L_0, L_1, Z, r_1-r_4, and R_{01}-R_{04}.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037]

FIG. 1 shows an organic light emitting device.

FIG. 2 shows an inverted organic light emitting device that does not have a separate electron transport layer.

FIG. 3 shows a plot of device lifetimes.

DETAILED DESCRIPTION

[0038] Generally, an OLED comprises at least one organic layer disposed between and electrically connected to an anode and a cathode. When a current is applied, the anode injects holes and the cathode injects electrons into the organic layer(s). The injected holes and electrons each migrate toward the oppositely charged electrode. When an electron and hole localize on the same molecule, an "exciton," which is a localized electron-hole pair having an excited energy state, is formed. Light is emitted when the exciton relaxes via a photoemissive mechanism. In some cases, the exciton may be localized on an excimer or an exciplex. Non-radiative mechanisms, such as thermal relaxation, may also occur, but are generally considered undesirable.

[0039] The initial OLEDs used emissive molecules that emitted light from their singlet states ("fluorescence") as disclosed, for example, in U.S. Pat. No. 4,769,292. Fluorescent emission generally occurs in a time frame of less than 10 nanoseconds.

[0040] More recently, OLEDs having emissive materials that emit light from triplet states ("phosphorescence") have been demonstrated. Baldo et al., "Highly Efficient Phosphorescent Emission from Organic Electroluminescent Devices," Nature, vol. 395, 151-154, 1998; ("Baldo-I") and Baldo et al., "Very high-efficiency green organic light-emitting devices based on electrophosphorescence," Appl. Phys. Lett., vol. 75, No. 3, 4-6 (1999) ("Baldo-II"). Phosphorescence is described in more detail in US Pat. No. 7,279,704 at cols. 5-6.

[0041] FIG. 1 shows an organic light emitting device 100. The figures are not necessarily drawn to scale. Device 100 may include a substrate 110, an anode 115, a hole injection layer 120, a hole transport layer 125, an electron blocking layer 130, an emissive layer 135, a hole blocking layer 140, an electron transport layer 145, an electron injection layer 150, a protective layer 155, and a cathode 160. Cathode 160 is a compound cathode having a first conductive layer 162 and a second conductive layer 164. Device 100 may be fabricated by depositing the layers described, in order. The properties and functions of these various layers, as well as example materials, are described in more detail in US 7,279,704 at cols. 6-10.

[0042] More examples for each of these layers are available. For example, a flexible and transparent substrate-anode combination is disclosed in U.S. Pat. No. 5,844,363. An example of a p-doped hole transport layer is m-MTDATA doped with F.sub.4-TCNQ at a molar ratio of 50:1, as disclosed in U.S. Patent Application Publication No. 2003/0230980. Examples of emissive and host materials are disclosed in U.S. Pat. No. 6,303,238 to Thompson et al. An example of an n-doped electron transport layer is BPhen doped with Li at a molar ratio of 1:1, as disclosed in U.S. Patent Application Publication No. 2003/0230980. U.S. Pat. Nos. 5,703,436 and 5,707,745 disclose examples of cathodes including compound cathodes having a thin layer of metal such as Mg:Ag with an overlying transparent, electrically-conductive, sputter-deposited ITO layer. The theory and use of blocking layers is described in more detail in U.S. Pat. No. 6,097,147 and U.S. Patent Application Publication No. 2003/0230980. Examples of injection layers are provided in U.S. Patent Application Publication No. 2004/0174116. A description of protective layers may be found in U.S. Patent Application Publication No. 2004/0174116.

[0043] FIG. 2 shows an inverted OLED 200. The device includes a substrate 210, a cathode 215, an emissive layer 220, a hole transport layer 225, and an anode 230. Device 200 may be fabricated by depositing the layers described, in order. Because the most common OLED configuration has a cathode disposed over the anode, and device 200 has cathode 215 disposed under anode 230, device 200 may be referred to as an "inverted" OLED. Materials similar to those

described with respect to device 100 may be used in the corresponding layers of device 200. FIG. 2 provides one example of how some layers may be omitted from the structure of device 100.

[0044] The simple layered structure illustrated in FIGs. 1 and 2 is provided by way of nonlimiting example, and it is understood that embodiments of the invention may be used in connection with a wide variety of other structures. The specific materials and structures described are exemplary in nature, and other materials and structures may be used. Functional OLEDs may be achieved by combining the various layers described in different ways, or layers may be omitted entirely, based on design, performance, and cost factors. Other layers not specifically described may also be included. Materials other than those specifically described may be used. Although many of the examples provided herein describe various layers as comprising a single material, it is understood that combinations of materials, such as a mixture of host and dopant, or more generally a mixture, may be used. Also, the layers may have various sublayers. The names given to the various layers herein are not intended to be strictly limiting. For example, in device 200, hole transport layer 225 transports holes and injects holes into emissive layer 220, and may be described as a hole transport layer or a hole injection layer. In one embodiment, an OLED may be described as having an "organic layer" disposed between a cathode and an anode. This organic layer may comprise a single layer, or may further comprise multiple layers of different organic materials as described, for example, with respect to FIGs. 1 and 2.

[0045] Structures and materials not specifically described may also be used, such as OLEDs comprised of polymeric materials (PLEDs) such as disclosed in U.S. Pat. No. 5,247,190 to Friend et al. By way of further example, OLEDs having a single organic layer may be used. OLEDs may be stacked, for example as described in U.S. Pat. No. 5,707,745 to Forrest et al. The OLED structure may deviate from the simple layered structure illustrated in FIGs. 1 and 2. For example, the substrate may include an angled reflective surface to improve out-coupling, such as a mesa structure as described in U.S. Pat. No. 6,091,195 to Forrest et al., and/or a pit structure as described in U.S. Pat. No. 5,834,893 to Bulovic et al.

[0046] Unless otherwise specified, any of the layers of the various embodiments may be deposited by any suitable method. For the organic layers, preferred methods include thermal evaporation, ink-jet, such as described in U.S. Pat. Nos. 6,013,982 and 6,087,196, organic vapor phase deposition (OVPD), such as described in U.S. Pat. No. 6,337,102 to Forrest et al., and deposition by organic vapor jet printing (OVJP), such as described in U.S. patent application Ser. No. 10/233,470. Other suitable deposition methods include spin coating and other solution based processes. Solution based processes are preferably carried out in nitrogen or an inert atmosphere. For the other layers, preferred methods include thermal evaporation. Preferred patterning methods include deposition through a mask, cold welding such as described in U.S. Pat. Nos. 6,294,398 and 6,468,819, and patterning associated with some of the deposition methods such as ink-jet and OVJD. Other methods may also be used. The materials to be deposited may be modified to make them compatible with a particular deposition method. For example, substituents such as alkyl and aryl groups, branched or unbranched, and preferably containing at least 3 carbons, may be used in small molecules to enhance their ability to undergo solution processing. Substituents having 20 carbons or more may be used, and 3-20 carbons is a preferred range. Materials with asymmetric structures may have better solution processibility than those having symmetric structures, because asymmetric materials may have a lower tendency to recrystallize. Dendrimer substituents may be used to enhance the ability of small molecules to undergo solution processing.

[0047] Devices fabricated in accordance with embodiments of the invention may be incorporated into a wide variety of consumer products, including flat panel displays, computer monitors, televisions, billboards, lights for interior or exterior illumination and/or signaling, heads up displays, fully transparent displays, flexible displays, laser printers, telephones, cell phones, personal digital assistants (PDAs), laptop computers, digital cameras, camcorders, viewfinders, micro-displays, vehicles, a large area wall, theater or stadium screen, or a sign. Various control mechanisms may be used to control devices fabricated in accordance with the present invention, including passive matrix and active matrix. Many of the devices are intended for use in a temperature range comfortable to humans, such as 18 degrees C. to 30 degrees C., and more preferably at room temperature (20-25 degrees C.).

[0048] The materials and structures described herein may have applications in devices other than OLEDs. For example, other optoelectronic devices such as organic solar cells and organic photodetectors may employ the materials and structures. More generally, organic devices, such as organic transistors, may employ the materials and structures.

[0049] The terms halo, halogen, alkyl, cycloalkyl, alkenyl, alkynyl, arylkyl, heterocyclic group, aryl, aromatic group, and heteroaryl are known to the art, and are defined in US 7,279,704 at cols. 31-32.

[0050] A method of fabricating an organic light emitting device by solution depositing an organic layer comprising an organic electron donor and an organic electron acceptor, which forms a layer insoluble to a non-polar solvent, is provided. Preferably, the organic layer forms a hole injection layer (HIL) in the device. The HIL is a particularly important organic layer in an OLED, because it helps provide holes to the emissive material in the emissive layer.

[0051] For solution processed OLEDs, an organic layer must be resistant to the solvent used in the next organic layer. Previously, there were only two methods available to provide an organic layer resistant to subsequent layers. First, an orthogonal solvent may be used, such as PEDOT/PSS in aqueous solution. Second, cross-linkable polymers may be used. In the second instance, the film becomes insoluble after the layer is treated to crosslink the polymers. (*See*, *e.g.*,

WO2008073440).

[0052] Here, a mixture of non-cross-linkable organic compounds forms a layer insoluble to a non-polar solvent used in a subsequent organic layer. As used herein, a "non-polar solvent" has a polarity index equal to or less than 3.5. The polarity index is defined in the Solvent Miscibility Table in the Appendix of the Phenomenex catalog (also see, http://www.chemical-ecology.net/java/solvents.htm). The insoluble organic layer includes an organic electron donor, e.g., a triarylamine derivative, and an organic electron acceptor, e.g., azatriphenylene. Especially preferred organic electron donors have an oxidation potential less than 0.6 V vs Fc^+/Fc. Organic electron acceptors have a first reduction potential high than -1.0 V vs Fc^+/Fc. Without being bound by theory, it is believed that the organic electron donor and the organic electron acceptor form an ionic charge transfer complex, thereby creating a layer insoluble to a non-polar solvent.

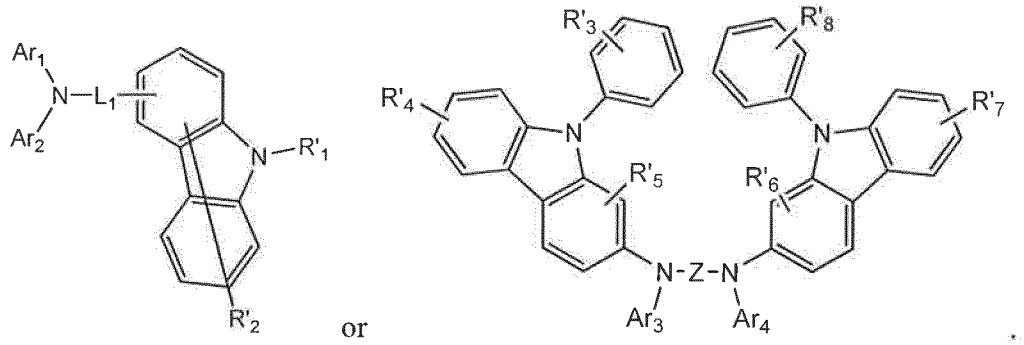
[0053] Vacuum thermal evaporation OLEDs containing triarylamine derivatives have been reported in the literature. (*See*, e.g., US2008107919A1, US2008124572A1, and US6344283B1). In particular, the use of p-doped triarylamine derivatives as HIL materials for vacuum thermal evaporation OLEDs has been reported. (*See* Walzer et al., Chemical Review, 2007, 107, 1233). Solution-processed OLEDs comprising an insoluble layer of triarylamine in combination with an inorganic electron donor, where the layer is embedded in metal oxide, have also been reported. (*See* Suzuki et al., SID Digest, 2007, 1840-1843). However, an organic layer containing a non-cross-linkable triarylamine derivative in combination with an organic electron acceptor has not been reported. The formation of a good organic layer film using these compounds was unexpected for several reasons. The properties of the compounds suggest that they would make poor films for a solution processed multilayer device. In particular, the crystallinity of triarylamine derivatives and the azatriphenylene suggests poor film formation. Further, these compounds have been traditionally used in OLEDs in which layers were deposited using VTE processing, a method very different from solution-processing.

[0054] Moreover, formation of an insoluble layer upon heating the triarylamine derivative and conductivity dopant composition was surprising. It would be expected that the film would have very poor solvent resistance, thus unsuitable for use in a solution processed multilayer device. If heated separately, the compounds would not become insoluble. Here, heating the organic layer comprising the organic electron donor, i.e., triarylamine derivative, and the organic electron acceptor, i.e., azatriphenylene, unexpectedly resulted in formation of a layer insoluble to a non-polar solvent. There are no prior reports of an insoluble organic layer comprising small molecule compounds that do not require cross-linking. Thus, there was no expectation that these small molecule materials would become insoluble when heated. The insoluble layer described herein is especially beneficial for fabrication of solution processed OLEDs.

[0055] Further, devices comprising an organic layer containing the organic electron donor, i.e., triarylamine derivative, and the organic electron acceptor, i.e., azatriphenylene, may have improved properties, including longer lifetime, good reproducibility, lower operating voltage while maintaining luminous efficiency, and improved purification, as illustrated in FIG 3.

[0056] A method of fabricating an organic light emitting device according to claim 1 is provided. The method comprises providing an electrode, depositing a first organic layer in contact with the electrode by a solution process, and heating the first organic layer to form a layer that is insoluble in a non-polar solvent. Preferably, the electrode is an anode. The first organic layer is deposited in contact with the anode.

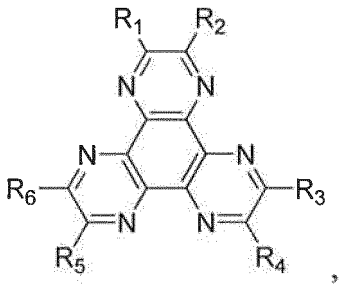
[0057] The first organic layer comprises a non-crosslinkable organic electron acceptor and a non-crosslinkable organic electron donor, wherein the non-crosslinkable organic electron donor has the formula:



[0058] L_1 represents a substituted or unsubstituted arylene group having 6 to 60 carbon atoms forming the aromatic ring, a substituted or unsubstituted fluorenylene group, or a substituted or unsubstituted heteroarylene group having 5 to 60 atoms forming a ring; Ar_1 and Ar_2 each independently represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic ring or a substituted or unsubstituted heteroaryl group having 5 to 60 atoms forming a ring; R'_1 represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic ring; $R'Z_2$ represents a hydrogen atom, a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming

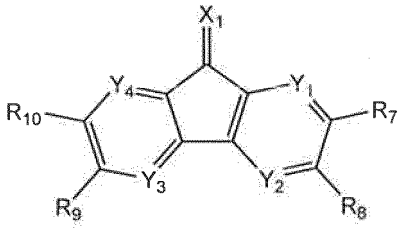
the aromatic ring, a substituted or unsubstituted alkyl group having 1 to 50 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 50 carbon atoms, a substituted or unsubstituted aryloxy group having 6 to 50 atoms forming a ring, a substituted or unsubstituted arylthio group having 5 to 50 atoms forming a ring, a substituted or unsubstituted alkoxycarbonyl group having 2 to 50 carbon atoms, an amino group substituted by a substituted or unsubstituted aryl group having 6 to 50 carbon atoms forming the aromatic ring, a halogen atom, a cyano group, a nitro group, a hydroxyl group or a carboxyl group; with the proviso that neither Ar_1 nor Ar_2 contains a fluorene structure, and that the number of a carbazole structures in the aromatic amine derivative represented by the formula is 1 or 2. Z is selected from the group consisting of a substituted or unsubstituted C1-C30 alkylene group, a substituted or unsubstituted C2-C30 alkenylene group, a substituted or unsubstituted. C6-C30 arylene group, a substituted or unsubstituted C2-C30 heteroarylene group, and a substituted or unsubstituted C2-C30 heterocyclic group; each of R'_3, R'_4, R'_5,R'_6, R'_7, and R'_8 is independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C1-C30 alkyl group, a substituted or unsubstituted C1-C30 alkoxy group, a substituted or unsubstituted C6-C30 aryl group, a substituted or unsubstituted C6-C30 aryloxy group, a substituted or unsubstituted C2-C30 heterocyclic group, a substituted or unsubstituted C6-C30 condensed polycyclic group, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, and, alternatively, two or more adjacent groups among R'_3, R'_4, R'_5, R'_6, R'_7, and R'_8 can be connected to each other to form a saturated or unsaturated carbocycle; and wherein each of Ar_3 and Ar_4 are independently a substituted or unsubstituted C6-C30 aryl group or a substituted or unsubstituted C2-C30 heteroaryl group.

[0059] In one aspect, the non-crosslinkable organic electron acceptor is selected from the group consisting of:



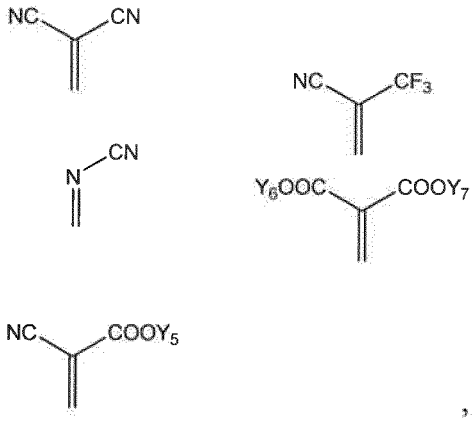
,

R_1, R_2, R_3, R_4, R_5, and R_6 are independently chosen from the group consisting of hydrogen, halogen, nitrile, nitro, sulfonyl, solfoxide, sulfonamide, sulfonate, trifluoromethyl, ester, amide, straight-chain or branched C1-C12 alkoxy, straight-chain or branched C1-C12 alkyl, aromatic or non-aromatic (substituted or unsubstituted) heterocyclic, substituted or unsubstituted aryl, mono- or di-(substituted or unsibstituted)aryl-amine, and (substituted or unsubstituted)alkyl-(substituted or unsubstituted)aryl-amine; or where R_1 and R_2, R_3 and R_4, and R_5 and R_6 combine form a ring structure including an aromatic ring, a heteroaromatic ring, or a non-aromatic ring, and each ring is substituted or unsubstituted;



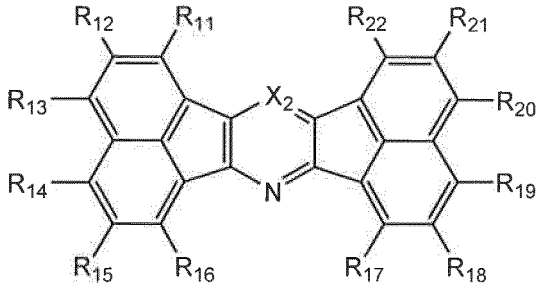
,

Y_1 to Y_4 are independently a carbon atom or a nitrogen atom. R_7 to R_{10} are independently a hydrogen atom, an alkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted heterocycle, a halogen atom, a fluoroalkyl group or a cyano group. R_7 and R_8, and R_9 and R_{10} are independently bonded to form a substituted or unsubstituted aromatic ring or a substituted or unsubstituted heterocycle. X_1 is selected from the group consisting of:



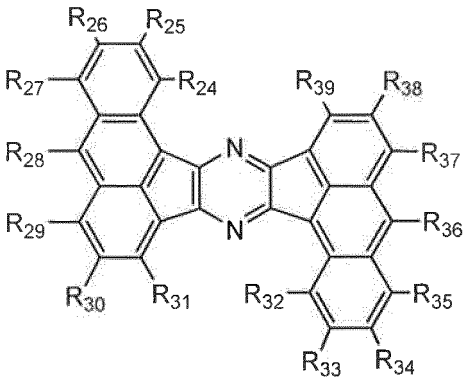
,

Y_5 to Y_7 are independently a hydrogen atom, a fluoroalkyl group, an alkyl group, an aryl group or a heterocyclic group; and Y_6 and Y_7 may form a ring;

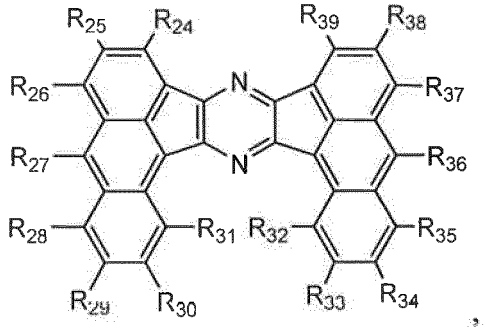


X_2 is

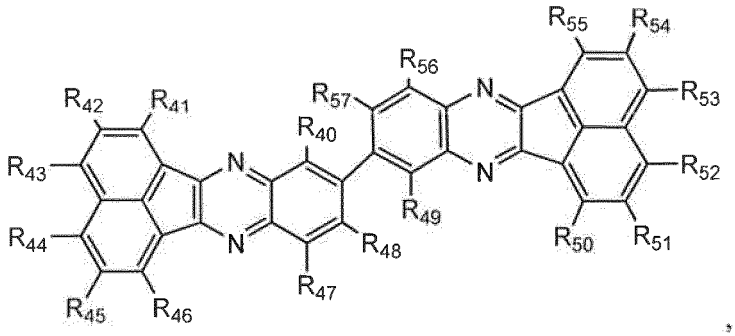
$C(R_{23})$ or N, R_{11} to R_{23} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{11} to R_{23} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{11} to R_{23}, which are adjacent to one another, may be linked together to form a ring structure;



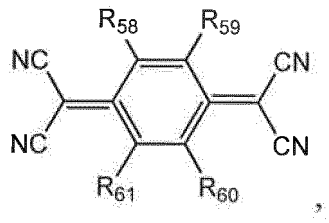
and



R_{24} to R_{39} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{24} to R_{39} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{24} to R_{39} which are adjacent to one another, may be linked together to form a ring structure;

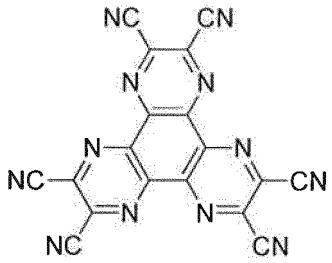


R_{40} to R_{57} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{40} to R_{57} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{40} to R_{57} which are adjacent to one another, may be linked together to form a ring structure; and



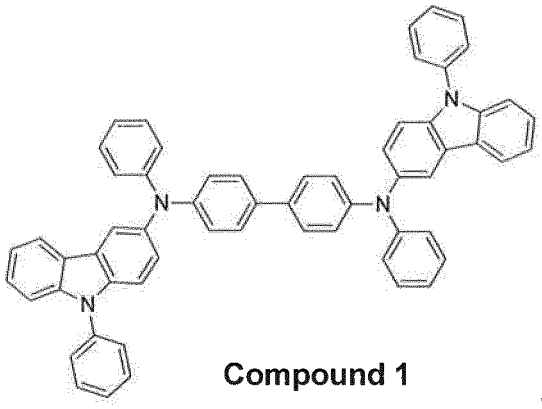
R_{58}-R_{61} independently represents hydrogen, fluorine, or substituents independently selected from nitrile (-CN), nitro ($-NO_2$), sulfonyl ($-SO_2R$), sulfoxide (-SOR), trifluoromethyl ($-CF_3$), ester (-CO-DR), amide (-CONHR or -CO-NRR'), substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or substituted or unsubstituted alkyl, where Rand R' include substituted or unsubstituted alkyl or aryl; or R_{58} and R_{59}, or R_{60} and R_{61}, combine form a ring structure including an aromatic ring, a heteroaromatic ring, or a non-aromatic ring, and each ring is substituted or unsubstituted.

[0060] Preferably, the non-crosslinkable organic electron acceptor is:



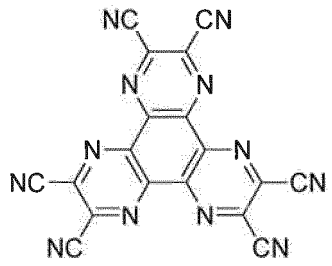
Dopant 1

[0061] Preferably, the non-crosslinkable organic electron donor is



Compound 1

[0062] More preferably, the non-crosslinkable organic electron acceptor is:

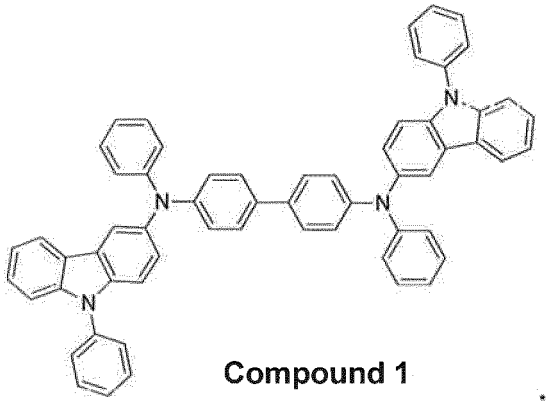


Dopant 1

,

and

the non-crosslinkable organic electron donor is



Compound 1

[0063] In one aspect, a second organic layer containing a non-polar solvent is deposited over the first organic layer, and the first organic layer is insoluble to the non-polar solvent in the second organic layer. Preferably, the first organic layer is a hole injection layer. Preferably, the second organic layer is a hole transporting layer, a hole blocking layer, an electron transporting layer, an electron injection layer, or an emissive layer.

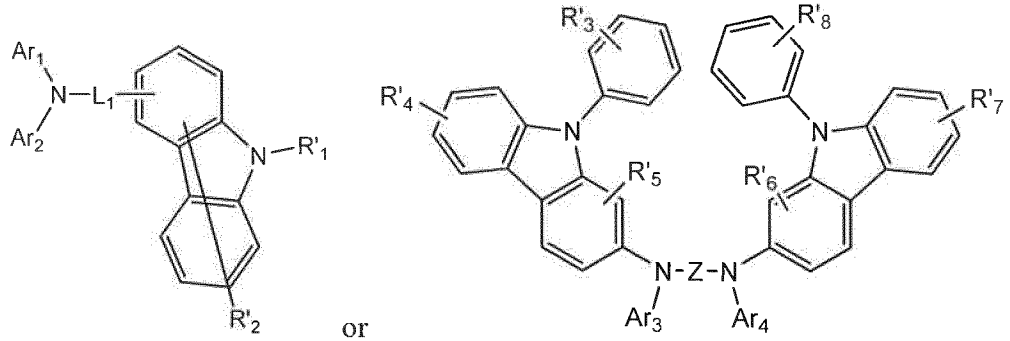
[0064] Non-polar solvents, as used herein, have a polarity index equal to or less than 3.5. Examples of non-polar solvents include, without limitation, benzene, carbon tetrachloride, cyclohexane, 1,2-dichloroethane, dichloromethane, di-ethyl ether, heptane, hexane, methyl-t-butyl ether, pentane, di-iso-propyl ether, toluene, and xylene. Preferably, the non-polar solvent is toluene.

[0065] In one aspect, the solution process is spin coating or inkjet printing.

[0066] In another aspect, the organic electron acceptor and the organic electron donor are mixed at a mole ratio of 1:1 or 2:1. Without being bound by theory, it is believed that the high mole ratio of the organic electron acceptor provides for good formation of the ionic complex between the organic electron acceptor and the organic electron donor. In doped VTE HILs, only a few percent of electron acceptor, normally less than 5%, is required to achieve efficient electron injection from the anode and high conductivity. It might not be enough, however, to form an insoluble layer with low electron acceptor percentage. For example, when the mole ratio of donor to acceptor is 1:20, the majority of the electron donor does not react with the electron acceptor. Therefore, a much higher electron acceptor concentration (mole ratio) may be needed.

[0067] In yet another aspect, the insoluble organic layer forms when the composition is heated at a temperature no less than about 100° C and no more than about 250° C. It is believed that the ionic complex formed between the organic electron acceptor and the organic electron donor forms more efficiently, solvent is better evaporated and materials do not breakdown within this temperature range.

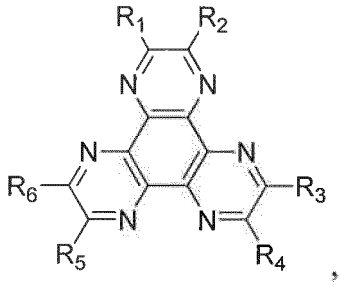
[0068] Additionally, a first device is provided, the device comprising an organic light emitting device, which further comprises an anode; a cathode; and a first organic layer disposed between the anode and the cathode, in contact with the anode or the cathode. The first organic layer comprises a non-crosslinkable organic electron acceptor and a non-crosslinkable organic electron donor having the formula:



[0069] L_1 represents a substituted or unsubstituted arylene group having 6 to 60 carbon atoms forming the aromatic ring, a substituted or unsubstituted fluorenylene group, or a substituted or unsubstituted heteroarylene group having 5 to 60 atoms forming a ring; An and Ar_2 each independently represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic ring or a substituted or unsubstituted heteroaryl group having 5 to 60 atoms forming a ring; R'_1 represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic

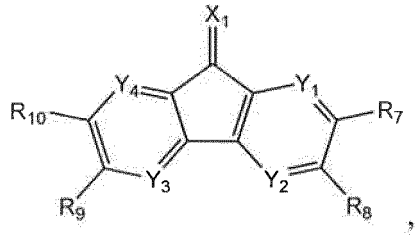
ring; R'_2 represents a hydrogen atom, a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic ring, a substituted or unsubstituted alkyl group having 1 to 50 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 50 carbon atoms, a substituted or unsubstituted aryloxy group having 6 to 50 atoms forming a ring, a substituted or unsubstituted arylthio group having 5 to 50 atoms forming a ring, a substituted or unsubstituted alkoxycarbonyl group having 2 to 50 carbon atoms, an amino group substituted by a substituted or unsubstituted aryl group having 6 to 50 carbon atoms forming the aromatic ring, a halogen atom, a cyano group, a nitro group, a hydroxyl group or a carboxyl group; with the proviso that neither Ar_1 nor Ar_2 contains a fluorene structure, and that the number of a carbazole structures in the aromatic amine derivative represented by the formula is 1 or 2. Z is selected from the group consisting of a substituted or unsubstituted C1-C30 alkylene group, a substituted or unsubstituted C2-C30 alkenylene group, a substituted or unsubstituted C6-C30 arylene group, a substituted or unsubstituted C2-C30 heteroarylene group, and a substituted or unsubstituted C2-C30 heterocyclic group; each of R'_3, R'_4, R'_5, R'_6, R'_7, and R'_8 is independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C1-C30 alkyl group, a substituted or unsubstituted C1-C30 alkoxy group, a substituted or unsubstituted C6-C30 aryl group, a substituted or unsubstituted C6-C30 aryloxy group, a substituted or unsubstituted C2-C30 heterocyclic group, a substituted or unsubstituted C6-C30 condensed polycyclic group, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, and, alternatively, two or more adjacent groups among R'_3, R'_4, R'_5, R'_6, R'_7, and R'_8 can be connected to each other to form a saturated or unsaturated carbocycle; and wherein each of Ar_3 and Ar_4 are independently a substituted or unsubstituted C6-C30 aryl group or a substituted or unsubstituted C2-C30 heteroaryl group.

[0070] In one aspect, the organic electron acceptor is selected from the group consisting of:



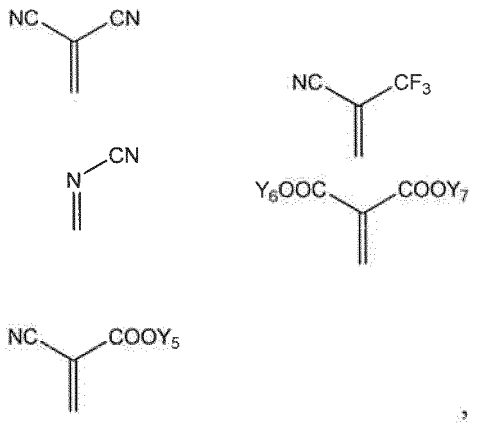
,

R_1, R_2, R_3, R_4, R_5, and R_6 are independently chosen from the group consisting of hydrogen, halogen, nitrile, nitro, sulfonyl, solfoxide, sulfonamide, sulfonate, trifluoromethyl, ester, amide, straight-chain or branched C1-C12 alkoxy, straight-chain or branched C1-C12 alkyl, aromatic or non-aromatic (substituted or unsubstituted) heterocyclic, substituted or unsubstituted aryl, mono- or di-(substituted or unsibstituted)aryl-amine, and (substituted or unsubstituted)alkyl-(substituted or unsubstituted)aryl-amine; or where R_1 and R_2, R_3 and R_4, and R_5 and R_6 combine form a ring structure including an aromatic ring, a heteroaromatic ring, or a non-aromatic ring, and each ring is substituted or unsubstituted;



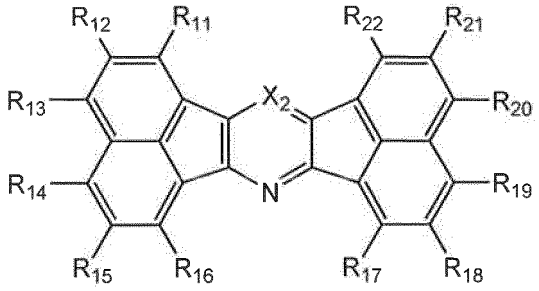
,

Y_1 to Y_4 are independently a carbon atom or a nitrogen atom. R_7 to R_{10} are independently a hydrogen atom, an alkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted heterocycle, a halogen atom, a fluoroalkyl group or a cyano group. R_7 and R_8, and R_9 and R_{10} are independently bonded to form a substituted or unsubstituted aromatic ring or a substituted or unsubstituted heterocycle. X_1 is selected from the group consisting of:



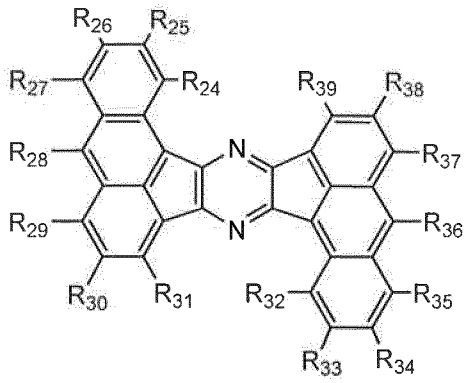
,

Y_5 to Y_7 are independently a hydrogen atom, a fluoroalkyl group, an alkyl group, an aryl group or a heterocyclic group; and Y_6 and Y_7 may form a ring;

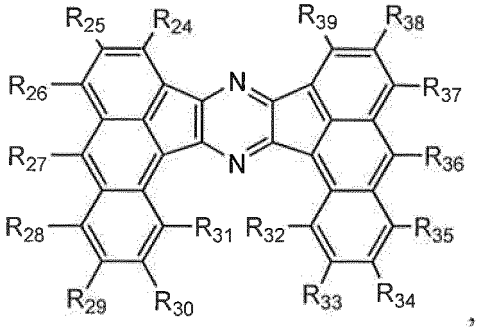


X_2 is

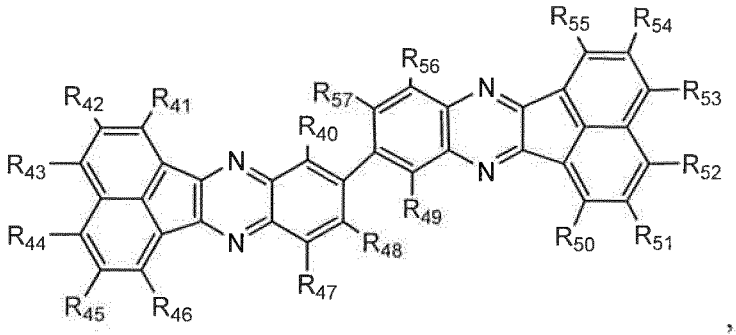
$C(R_{23})$ or N, R_{11} to R_{23} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{11} to R_{23} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{11} to R_{23}, which are adjacent to one another, may be linked together to form a ring structure;



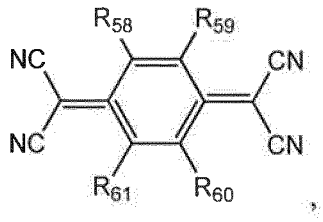
and



R_{24} to R_{39} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{24} to R_{39} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{24} to R_{39} which are adjacent to one another, may be linked together to form a ring structure;

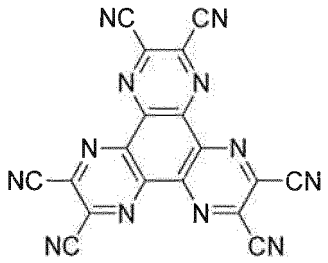


R_{40} to R_{57} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{40} to R_{57} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{40} to R_{57} which are adjacent to one another, may be linked together to form a ring structure; and



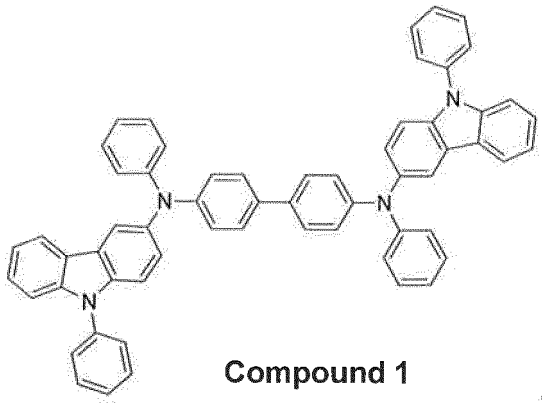
R_{58}-R_{61} independently represents hydrogen, fluorine,or substituents independently selected from nitrile (-CN), nitro (-NO_2), sulfonyl (-SO_2R), sulfoxide (-SOR), trifluoromethyl (-CF_3), ester (-CO-DR), amide (-CONHR or -CO-NRR'), substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or substituted or unsubstituted alkyl, where Rand R' include substituted or unsubstituted alkyl or aryl; or R_{58} and R_{59}, or R_{60} and R_{61}, combine form a ring structure including an aromatic ring, a heteroaromatic ring, or a non-aromatic ring, and each ring is substituted or unsubstituted.

[0071] Preferably, the organic electron acceptor has the formula:



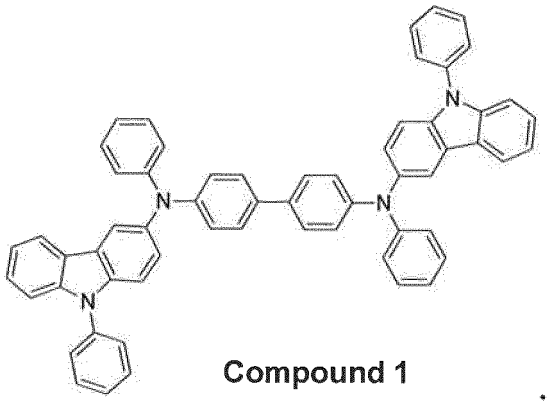
Dopant 1

[0072] Preferably, the organic electron donor is



Compound 1

[0073] More preferably, the organic electron acceptor is Dopant 1 and the organic electron donor is



Compound 1

[0074] In one aspect, the organic electron acceptor and the organic electron donor form a layer that is insoluble in a non-polar solvent having a polarity index equal to or less than 3.5. Examples of non-polar solvents include, without limitation, benzene, carbon tetrachloride, cyclohexane, 1,2-dichloroethane, dichloromethane, di-ethyl ether, heptane, hexane, methyl-t-butyl ether, pentane, di-iso-propyl ether, toluene, and xylene. Preferably, the non-polar solvent is toluene.

[0075] In one aspect, the first device is a consumer product. In another aspect, the first device is an organic light emitting device.

[0076] In another aspect, the layer that is insoluble in a non-polar solvent forms when the organic electron acceptor and the organic electron donor are heated at a temperature no less than about 100° C and no more than about 250° C. For reasons discussed above, it is believed that the ionic omplex between the organic electron acceptor and the organic electron donor forms more efficiently within this temperature range.

[0077] In one aspect, the organic electron acceptor and the organic electron donor are mixed at a mole ratio of 1:1 or 2:1.

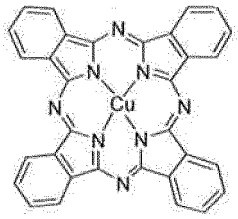
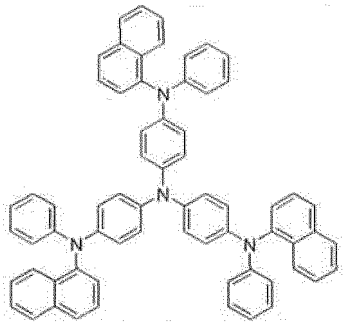
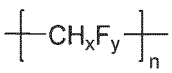
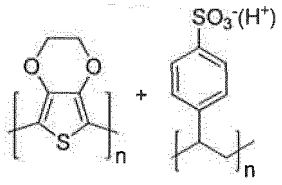
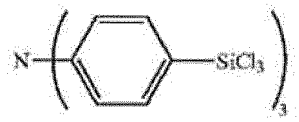
[0078] In another aspect, a second organic layer containing a non-polar solvent is deposited over the first organic layer, and the first organic layer is insoluble to the non-polar solvent contained in the second organic layer. Preferably,

the first organic layer is a hole injection layer. In yet a further aspect, the second organic layer is a hole transporting layer, a hole blocking layer, an electron transporting layer, an electron injection layer, or an emissive layer.

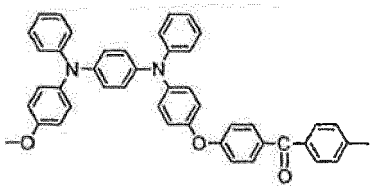
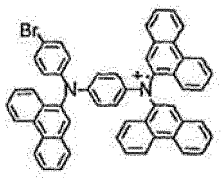
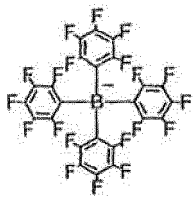
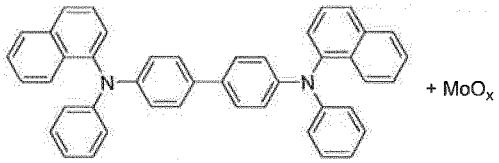
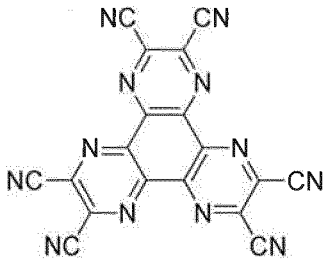
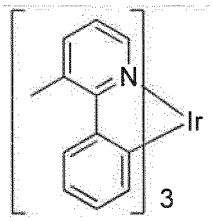
[0079] The materials described herein as useful for a particular layer in an organic light emitting device may be used in combination with a wide variety of other materials present in the device. For example, emissive dopants disclosed herein may be used in conjunction with a wide variety of hosts, transport layers, blocking layers, injection layers, electrodes and other layers that may be present. The materials described or referred to below are examples of materials that may be useful in combination with the compounds disclosed herein.

[0080] In addition to and / or in combination with the materials disclosed herein, many hole injection materials, hole transporting materials, host materials, dopant materials, exiton/hole blocking layer materials, electron transporting and electron injecting materials may be used in an OLED. Examples of the materials that may be used in an OLED in combination with materials disclosed herein are listed in Table 1 below. Table 1 lists classes of materials, examples of compounds for each class, and references that disclose the materials.

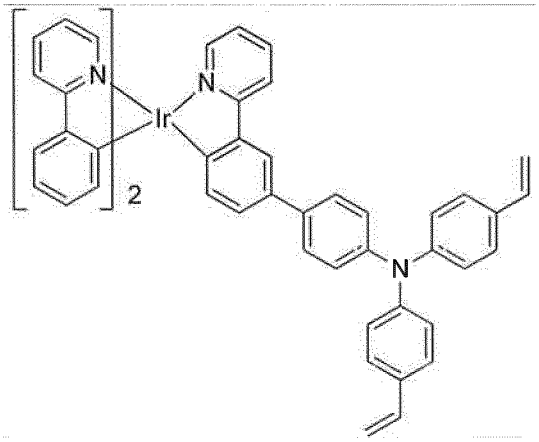
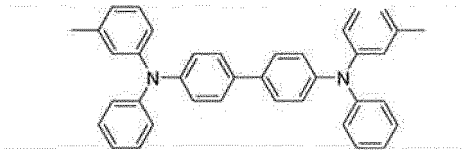
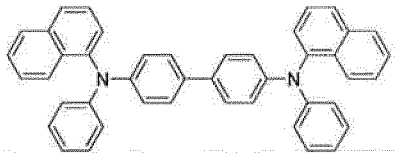
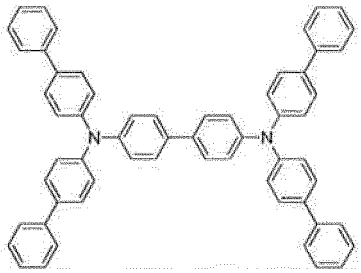
TABLE 1

MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Hole injection materials		
Phthalocyanine and porphryin compounds		Appl. Phys. Lett. 69, 2160 (1996)
Starburst triarylamines		J. Lumin. 72-74, 985 (1997)
CF_x Fluorohydrocarbon polymer		Appl. Phys. Lett. 78, 673 (2001)
Conducting polymers (e.g., PEDOT:PSS, polyaniline, polypthiophene)		Synth. Met. 87, 171 (1997) WO2007002683
Phosphonic acid and sliane SAMs		US20030162053

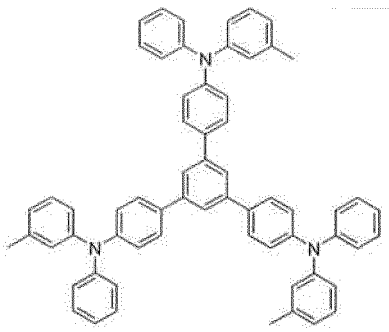
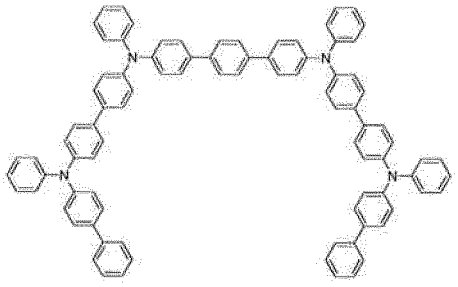
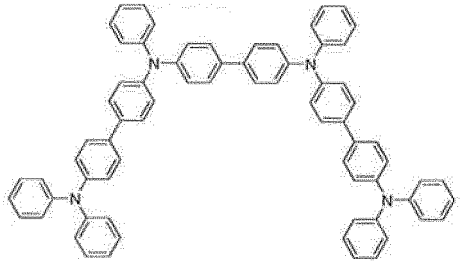
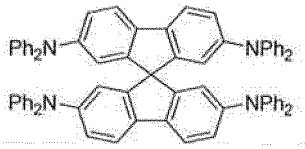
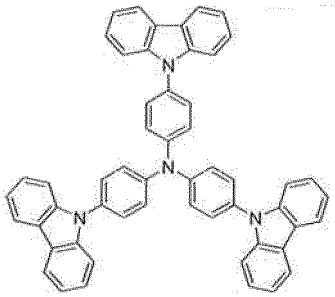
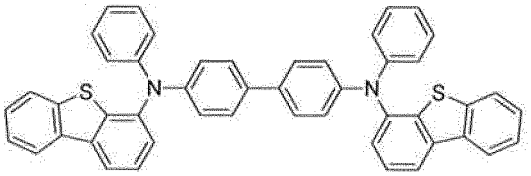
(continued)

MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Hole injection materials		
Triarylamine or polythiophene polymers with conductivity dopants	 and  	EA01725079A1
Arylamines complexed with metal oxides such as molybdenum and tungsten oxides		SID Symposium Digest, 37, 923 (2006) WO2009018009
p-type semiconducting organic complexes		US20020158242
Metal organometallic complexes		US20060240279

(continued)

MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Hole injection materials		
Cross-linkable compounds		US20080220265
Hole transporting materials		
Triarylamines (e.g., TPD, α-NPD)		Appl. Phys. Lett. 51, 913 (1987)
		US5061569
		EP650955

(continued)

Hole transporting materials		
		J. Mater. Chem. 3, 319 (1993)
		Appl. Phys. Lett. 90, 183503 (2007)
		Appl. Phys. Lett. 90, 183503 (2007)
Triaylamine on spirofluorene core		Synth. Met. 91, 209 (1997)
Arylamine carbazole compounds		Adv. Mater. 6, 677 (1994), US20080124572
Triarylamine with (di) benzothiophene/(di)benzofuran		US20070278938, US20080106190

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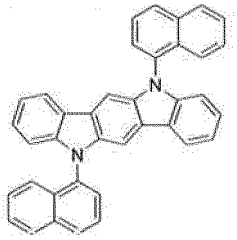
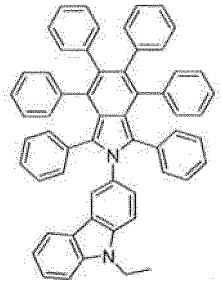
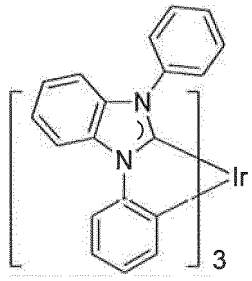
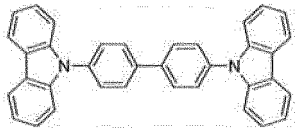
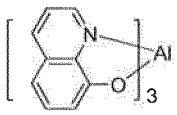
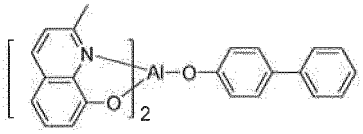
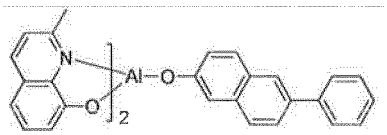
Hole transporting materials		
Indolocarbazoles		Synth. Met. 111, 421 (2000)
Isoindole compounds		Chem. Mater. 15, 3148 (2003)
Metal carbene complexes		US20080018221
Phosphorescent OLED host materials		
Red hosts		
Arylcarbazoles		Appl. Phys. Lett. 78, 1622 (2001)
Metal 8-hydroxyquinolates (e.g., Alq_3, BAlq)		Nature 395, 151 (1998)
		US20060202194
		WO20050 14551

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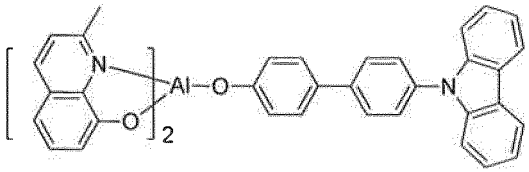
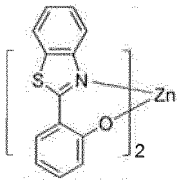
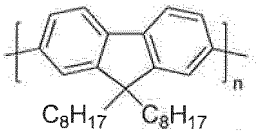
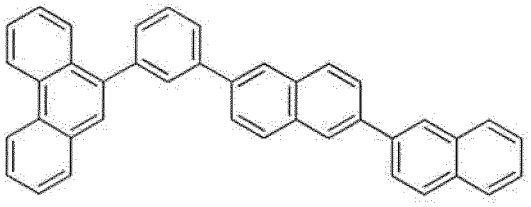
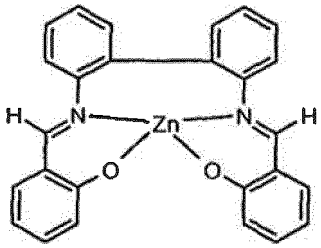
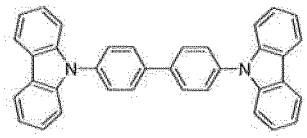
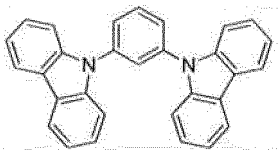
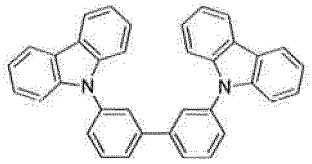
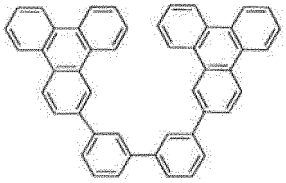
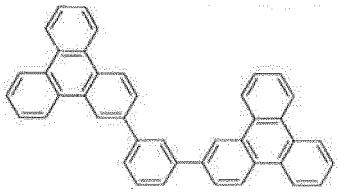
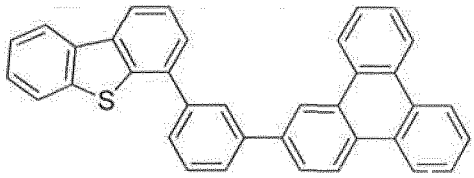
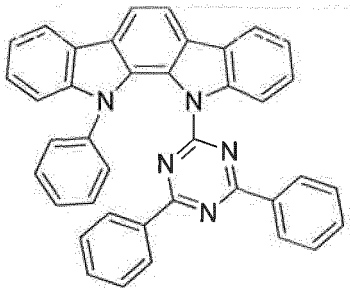
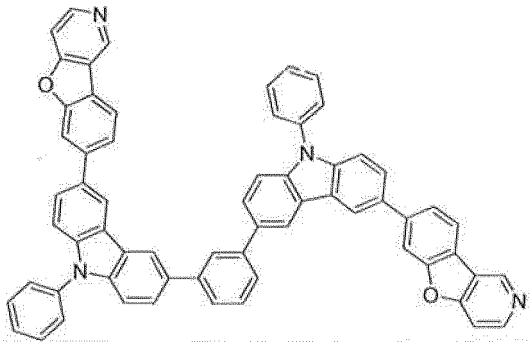
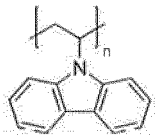
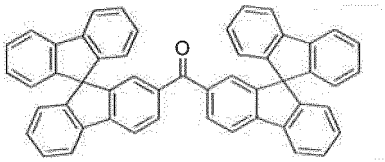
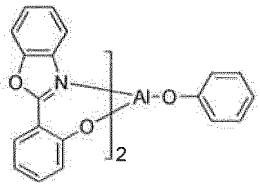
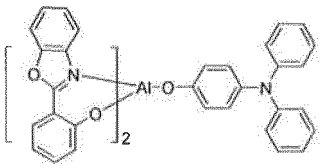
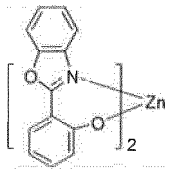
Phosphorescent OLED host materials		
Red hosts		
		WO2006072002
Metal phenoxybenzothiazole compounds		Appl. Phys. Lett. 90, 123509 (2007)
Conjugated oligomers and polymers (e.g., polyfluorene)		Org. Electron. 1, 15 (2000)
Aromatic fused rings		WO2009066779, WO2009066778, WO2009063833, US20090045731, US20090045730, WO2009008311, US20090008605, US20090009065
Zinc complexes		WO2009062578

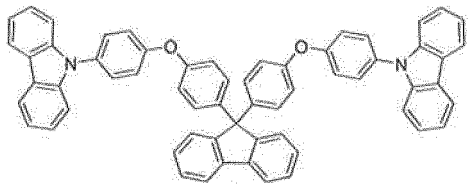
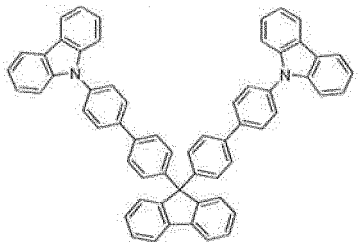
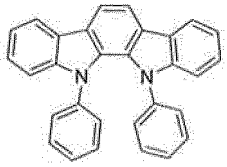
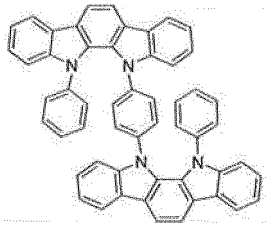
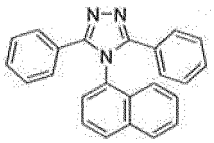
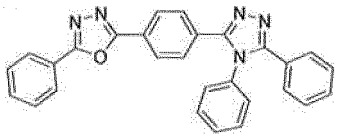
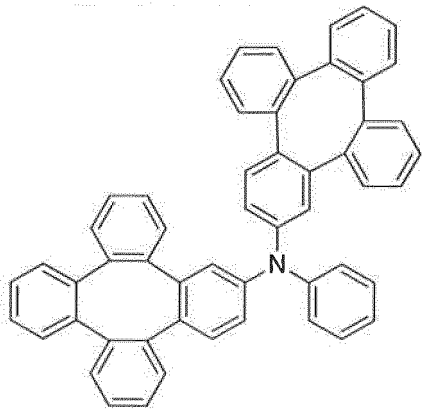
(continued)

Green hosts		
Arylcarbazoles		Appl. Phys. Lett. 78, 1622 (2001)
		US20030175553
		WO2001039234
Aryltriphenylene compounds		US20060280965
		US20060280965
		WO2009021126
Donor acceptor type molecules		WO2008056746

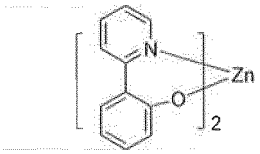
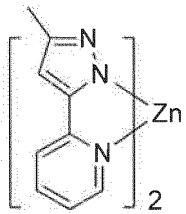
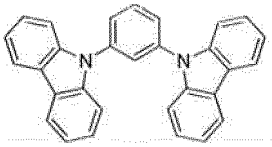
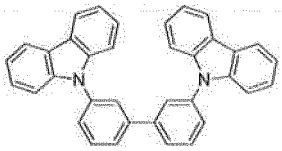
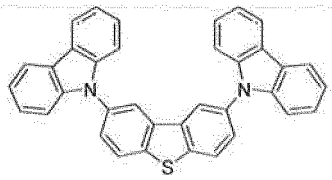
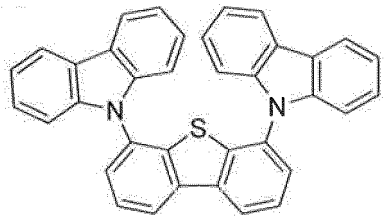
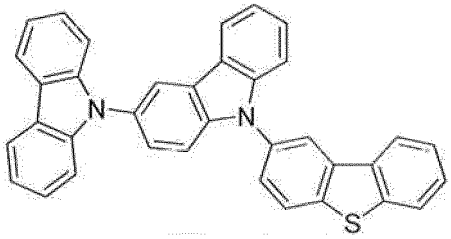
(continued)

Green hosts		
Aza-carbazole/DBT/DBF		JP2008074939
Polymers (e.g., PVK)		Appl. Phys. Lett. 77, 2280 (2000)
Spirofluorene compounds		WO2004093207
Metal phenoxybenzooxaxazole compounds		WO2005089025
		WO2006132173
		JP200511610

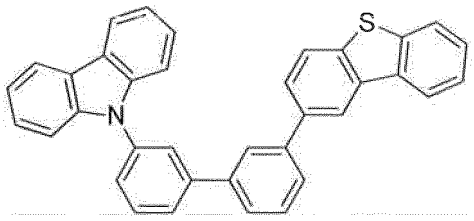
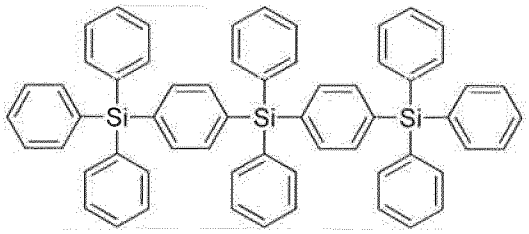
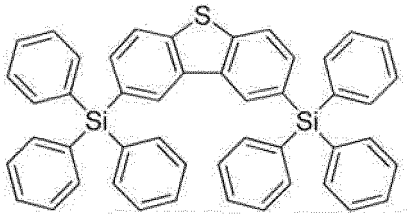
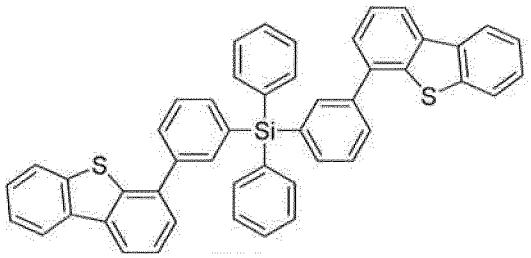
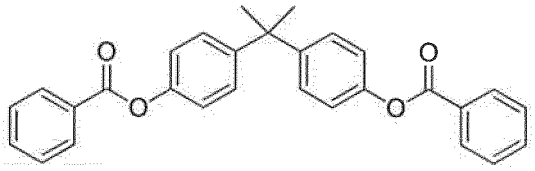
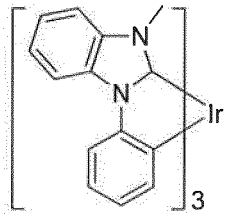
(continued)

Green hosts		
Spirofluorene-carbazole compounds		JP2007254297
		JP2007254297
Indolocabazoles		WO2007063796
		WO2007063754
5-member ring electron deficient heterocycles (e.g., triazole, oxadiazole)		J. Appl. Phys. 90, 5048 (2001)
		WO2004107822
Tetraphenylene complexes		US20050112407

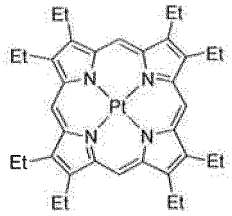
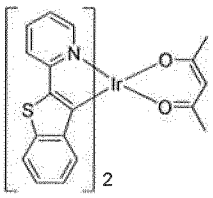
(continued)

Green hosts		
Metal phenoxypyridine compounds		WO2005030900
Metal coordination complexes (e.g., Zn, Al with N^N ligands)		US20040137268, US20040137267
Blue hosts		
Arylcarbazoles		Appl. Phys. Lett, 82, 2422 (2003)
		US20070190359
Dibenzothiophene/Dibenzofuran-carbazole compounds		WO2006114966, US20090167162
		US20090167162
		WO2009086028

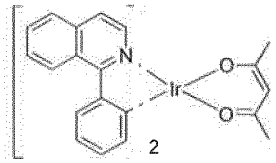
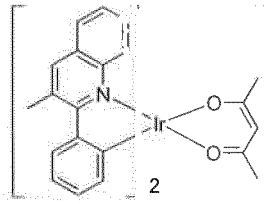
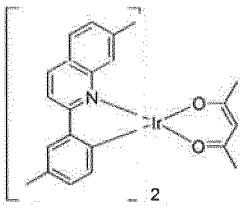
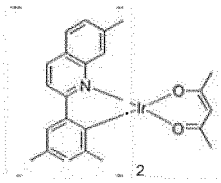
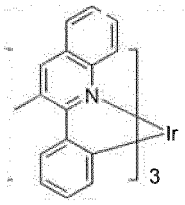
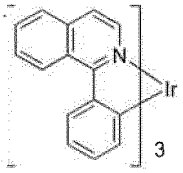
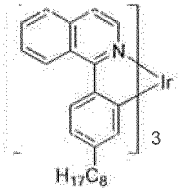
(continued)

Blue hosts		
		US20090030202, US20090017330
Silicon aryl compounds		US20050238919
		WO2009003898
Silicon/Germanium aryl compounds		EP2034538A
Aryl benzoyl ester		WO2006100298
High triplet metal organometallic complex		US7154114

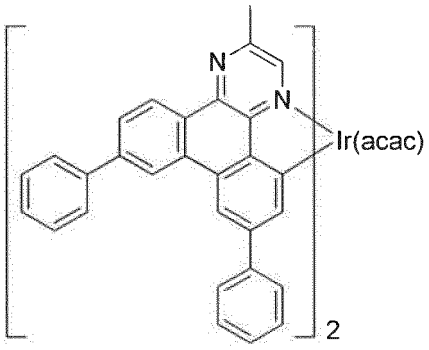
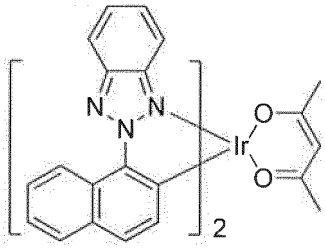
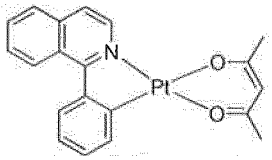
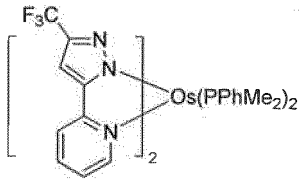
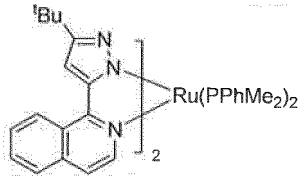
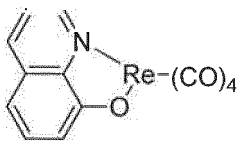
(continued)

Phosphorescent dopants		
Red dopants		
Heavy metal porphyrins (e.g., PtOEP)		Nature 395, 151 (1998)
Iridium(III) organometallic complexes		Appl. Phys. Lett. 78, 1622 (2001)

(continued)

Phosphorescent dopants		
Red dopants		
		US2006835469
		US2006835469
		US20060202194
		US20060202194
		US20070087321
		US20070087321
		Adv. Mater. 19, 739 (2007)

(continued)

Phosphorescent dopants		
Red dopants		
		WO2009100991
		WO2008101842
Platinum(II) organometallic complexes		WO2003040257
Osminum(III) complexes		Chem. Mater. 17, 3532 (2005)
Ruthenium(II) complexes		Adv. Mater. 17, 1059 (2005)
Rhenium (I), (II), and (III) complexes		US20050244673

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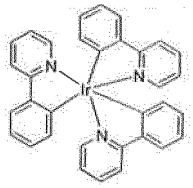
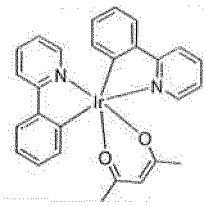
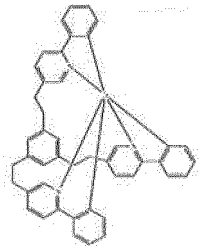
Green dopants		
Iridium(III) organometallic complexes	 and its derivatives	Inorg. Chem. 40, 1704 (2001)
		US20020034656
		US7332232

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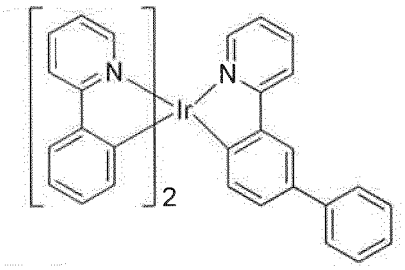
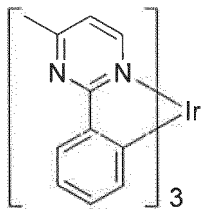
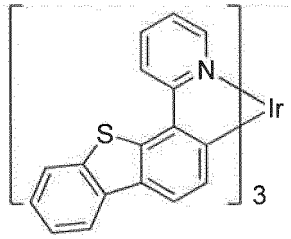
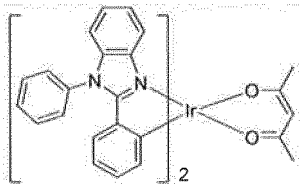
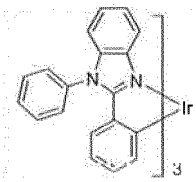
Green dopants		
		US20090108737
		US20090039776
		US6921915
		US6687266
		Chem. Mater. 16, 2480 (2004)

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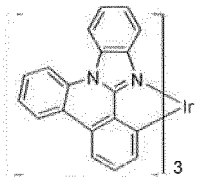
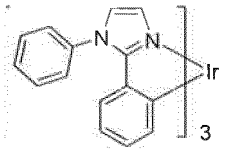
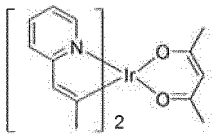
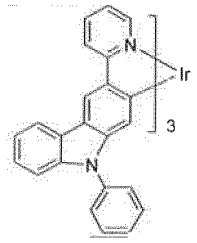
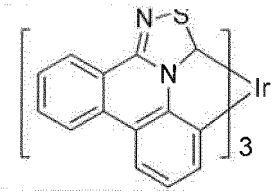
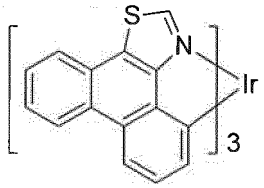
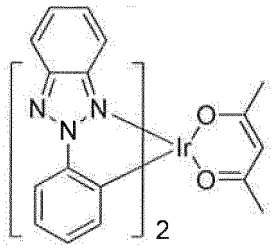
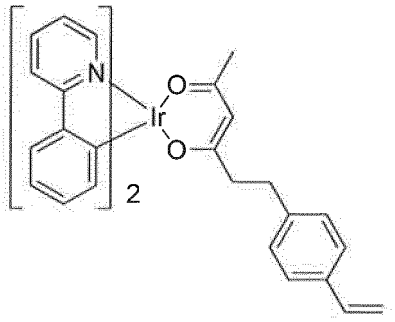
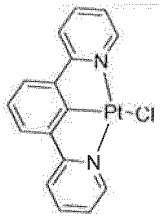
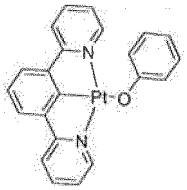
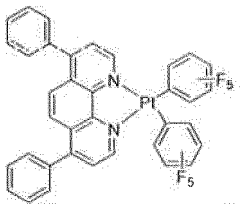
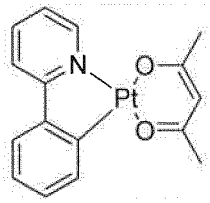
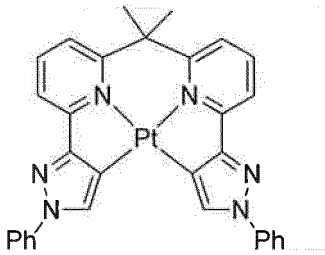
Green dopants		
		US20070190359
		US 20060008670 JP2007123392
		Adv. Mater. 16, 2003 (2004)
		Angew. Chem. Int. Ed. 2006, 45, 7800
		WO2009050290
		US20090165846
		US20080015355

(continued)

Green dopants		
Monomer for polymeric metal organometallic compounds		US7250226, US7396598
Pt(II) organometallic complexes, including polydentated ligands		Appl. Phys. Lett. 86, 153505 (2005)
		Appl. Phys. Lett. 86, 153505 (2005)
		Chem. Lett. 34, 592 (2005)
		WO2002015645
		US20060263635

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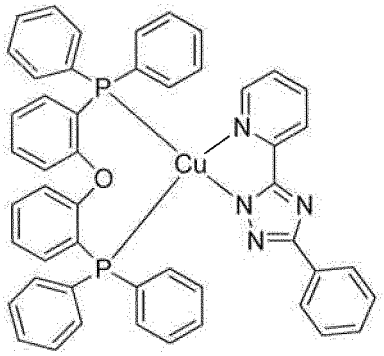
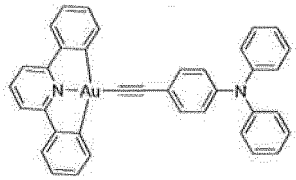
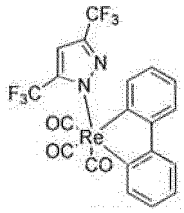
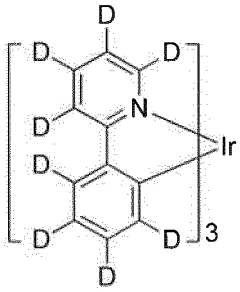
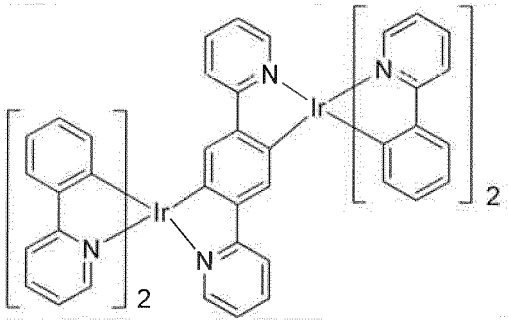
Green dopants		
Cu complexes		WO2009000673
Gold complexes		Chem. Commun. 2906 (2005)
Rhenium(III) complexes		Inorg. Chem. 42, 1248 (2003)
Deuterated organometallic complexes		US20030138657
Organometallic complexes with two or more metal centers		US20030152802

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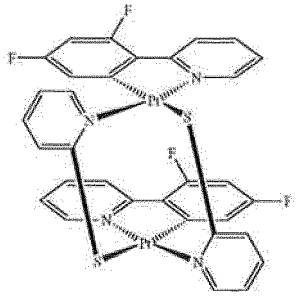
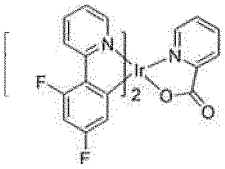
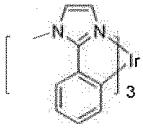
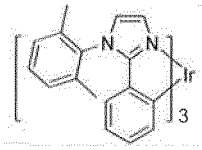
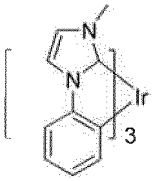
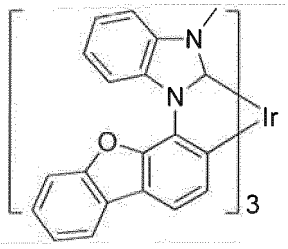
Green dopants		
		US7090928
Blue dopants		
Iridium(III) organometallic complexes		WO2002002714
		WO2006009024
		US20060251923
		US7393599, WO2006056418, US20050260441, WO2005019373
		US7534505

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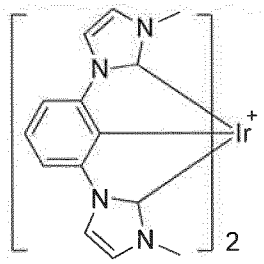
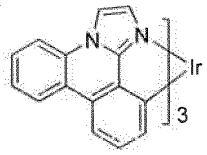
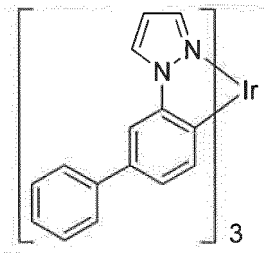
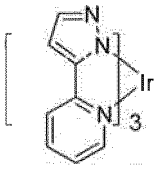
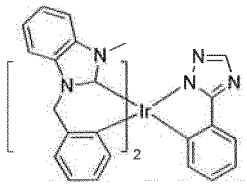
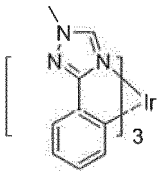
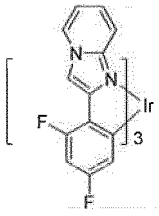
Blue dopants		
		US7445855
		US20070190359, US20080297033
		US7338722
		US20020 134984
		Angew. Chem. Int. Ed. 47, 1 (2008)
		Chem. Mater. 18, 5119 (2006)
		Inorg. Chem. 46, 4308 (2007)

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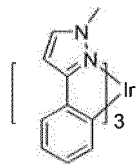
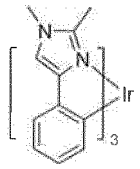
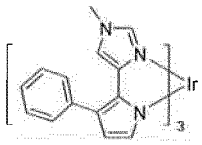
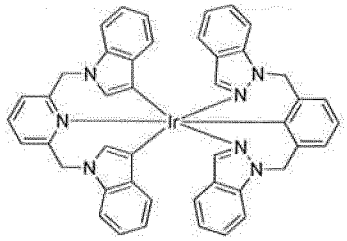
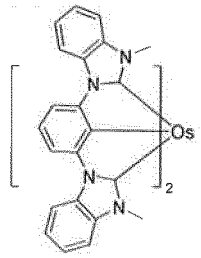
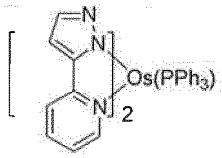
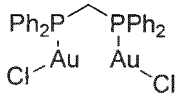
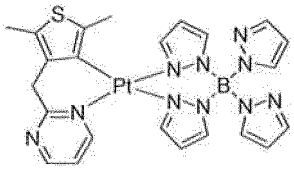
Blue dopants		
		WO2005123873
		WO2005123873
		WO2007004380
		WO2006082742
Osmium(II) complexes		US7279704
		Organometallics 23, 3745 (2004)
Gold complexes		Appl. Phys. Lett.74,1361 (1999)
Platinum(II) complexes		WO2006098120, WO2006103874

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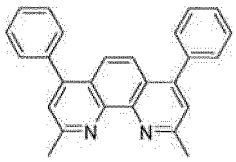
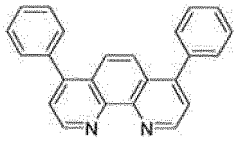
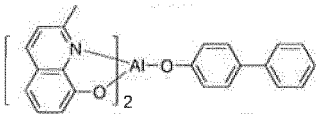
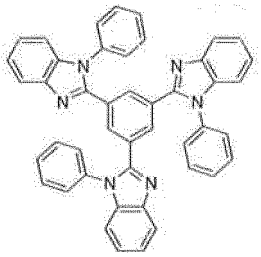
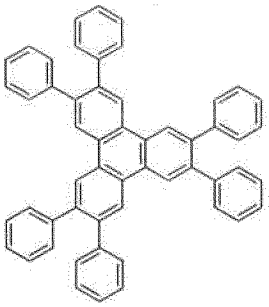
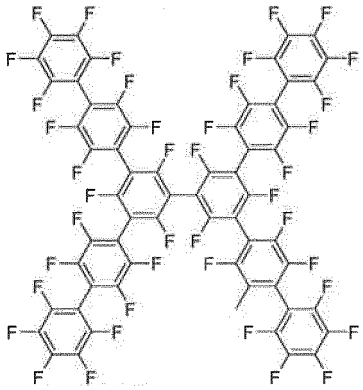
Exciton/hole blocking layer materials		
Bathocuprine compounds (e.g., BCP, BPhen)		Appl. Phys. Lett. 75, 4 (1999)
		Appl. Phys. Lett. 79, 449 (2001)
Metal 8-hydroxyquinolates (e.g., BAlq)		Appl. Phys. Lett. 81, 162 (2002)
5-member ring electron deficient heterocycles such as triazole, oxadiazole, imidazole, benzoimidazole		Appl. Phys. Lett. 81, 162 (2002)
Triphenylene compounds		US20050025993
Fluorinated aromatic compounds		Appl. Phys. Lett. 79, 156 (2001)

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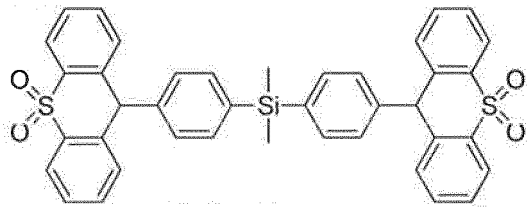
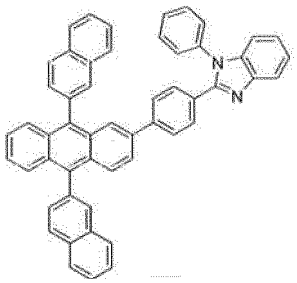
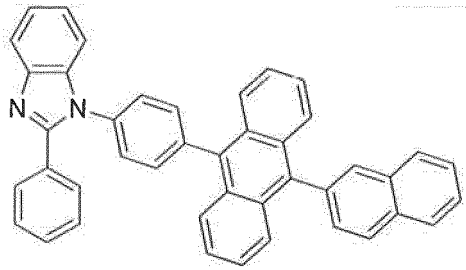
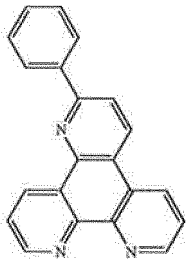
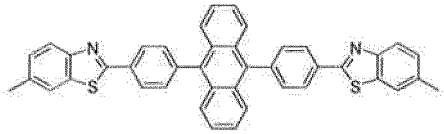
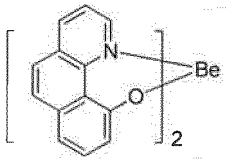
Exciton/hole blocking layer materials		
Phenothiazine-S-oxide		WO2008132085
Electron transporting materials		
Anthracene-benzoimidazole compounds		WO2003060956
		US20090179554
Aza triphenylene derivatives		US20090115316
Anthracene-benzothiazole compounds		Appl. Phys. Lett. 89, 063504 (2006)
Metal 8-hydroxyquinolates (e.g., Alq_3, Zrq4)		Appl. Phys. Lett. 51, 913 (1987) US7230107
Metal hydroxybenoquinolates		Chem. Lett. 5, 905 (1993)

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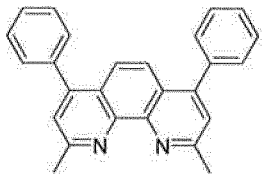
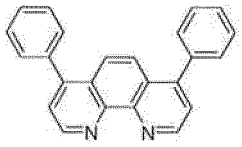
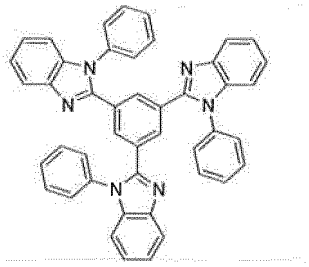
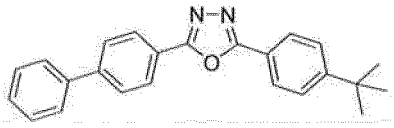
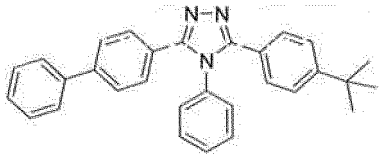
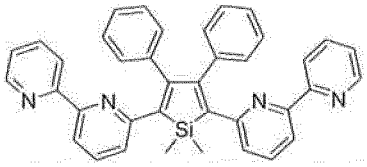
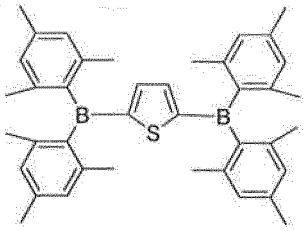
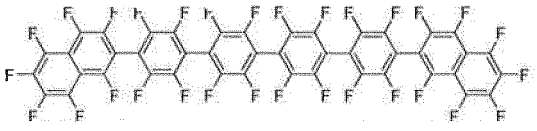
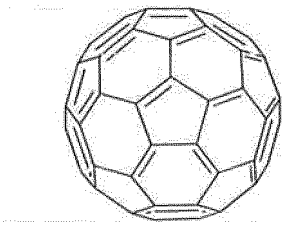
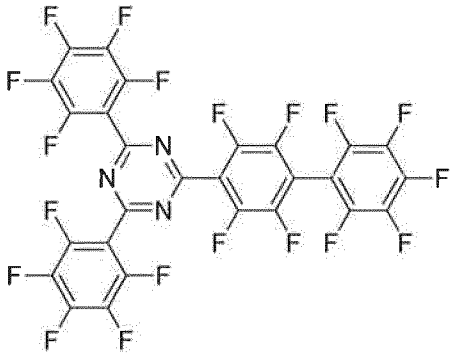
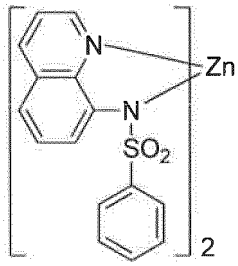
Electron transporting materials		
Bathocuprine compounds such as BCP, BPhen, etc		Appl. Phys. Lett. 91, 263503 (2007)
		Appl. Phys. Lett. 79, 449 (2001)
5-member ring electron deficient heterocycles (e.g.,triazole, oxadiazole, imidazole, benzoimidazole)		Appl. Phys. Lett. 74, 865 (1999)
		Appl. Phys. Lett. 55, 1489 (1989)
		Jpn. J. Apply. Phys. 32, L917 (1993)
Silole compounds		Org. Electron. 4, 113 (2003)
Arylborane compounds		J. Am. Chem. Soc. 120, 9714 (1998)
Fluorinated aromatic compounds		J. Am. Chem. Soc. 122, 1832 (2000)

(continued)

Electron transporting materials		
Fullerene (e.g., C60)		US20090101870
Triazine complexes		US20040036077
Zn (N^N) complexes		US6528187

EXPERIMENTAL

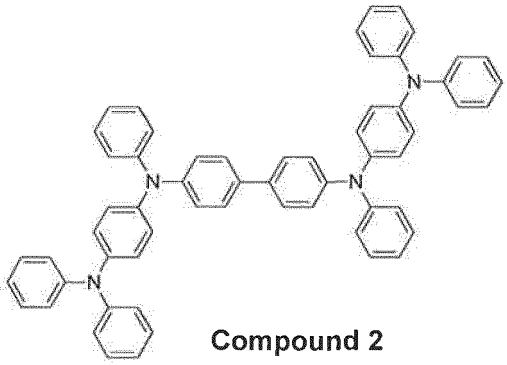
[0081] Several devices were fabricated as follows:
The hole injection layer (HIL) solutions were prepared by mixing the triarylamine derivative and conductivity dopant (mole ratio 1:1 or 2:1) in an organic solvent. Table 2 shows the composition of the HIL solutions. The HIL film was formed by spin coating the HIL solution at various speeds. The film was then baked at 250 °C.

TABLE 2.

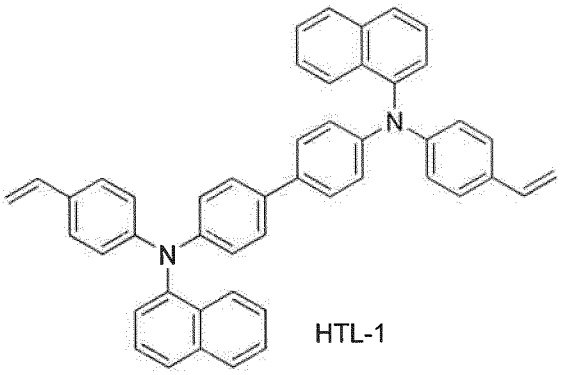
	Organic electron donor	Organic electron acceptor	Mole ratio	Solvent	Total concentration (mg/mL)
HIL1	Compound 1	Dopant 1	1:1	Cyclohexanone	15
Comparative HIL2	Compound 2	Dopant 1	1:1	Cyclohexanone	15
Comparative HIL3	Compound 2	Dopant 1	2:1	Cyclohexanone	13

[0082] Green-emitting OLEDs were made using HIL1, Comparative HIL2, and Comparative HIL3 for the hole injection layer. To form the HIL, the solution was spin-coated at 2500 rpm for 60 seconds onto a patterned indium tin oxide (ITO) electrode. The resulting film was baked for 30 minutes at 250° C.

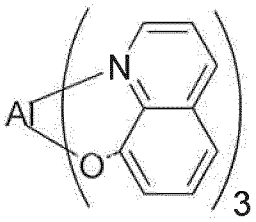
[0083] As used herein, the following compounds have the following structures:



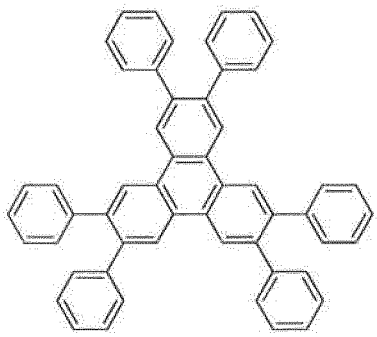
Compound 2



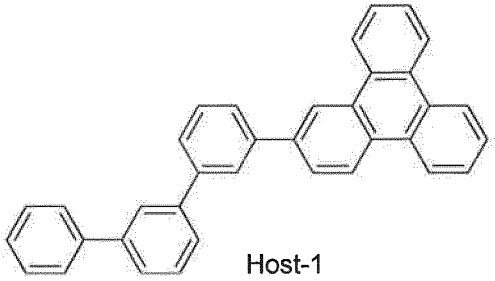
HTL-1



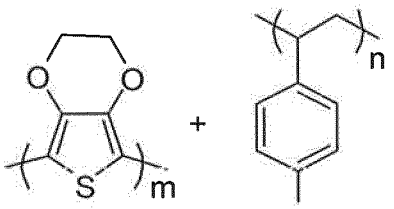
Alq_3



HPT

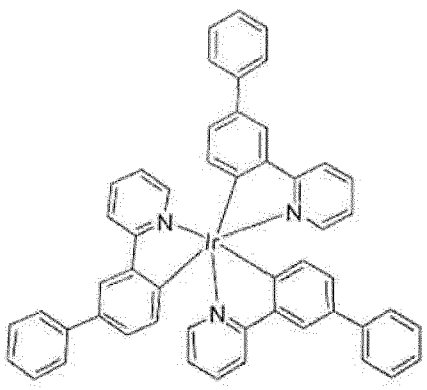


Host-1

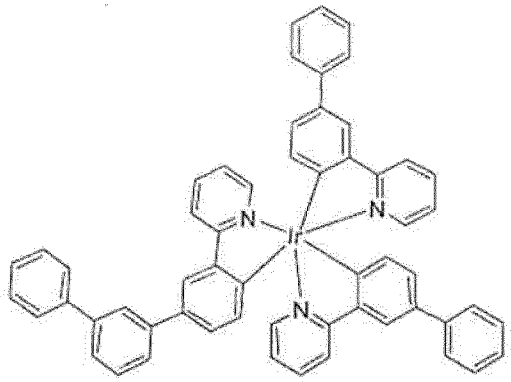


PEDOT:PSS

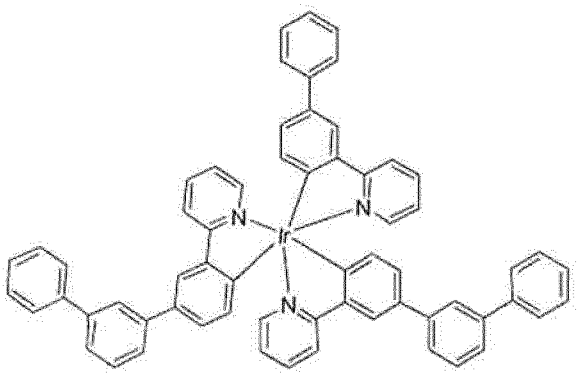
[0084] As used herein, Dopant 1 is a mixture of A, B, C, and D in a ratio of 1.9 : 18.0 : 46.7 : 32.8, wherein A, B, C, and D have the following structures:



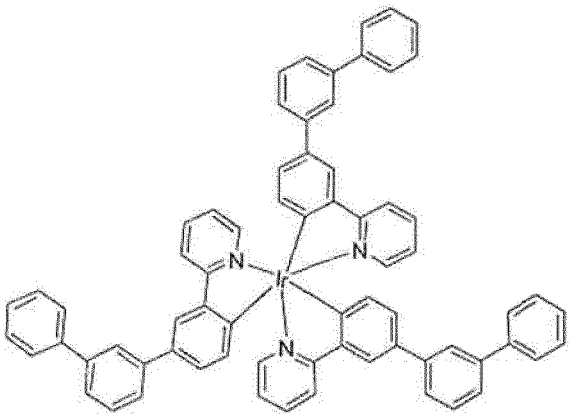
(A)



(B)



(C)



(D)

[0085] To check the insolubility, the HIL1 solution was spun-coated on the top of a Si-wafer, and the spin and baking conditions were same as on ITO. After baking, the HIL1 film was measured. Then, neat toluene solvent was spun on the top of HIL1 film to try wash-off the HIL 1 film, which is the same as the hole transporting layer (HTL) spin-coating process used in device fabrication. The HIL1 film thickness was measured with 133 Å before washing, and 86 Å after toluene washing. About 60% of the film thickness was left after toluene washing.

[0086] A comparative green-emitting device was fabricated using PEDOT:PSS (Baytron, CH8000) as the HIL material. The PEDOT:PSS in an aqueous dispersion was spin-coated at 4000 rpm for 60 seconds onto a patterned indium tin oxide (ITO) electrode. The resulting film was baked for 5 minutes at 200° C.

[0087] On top of the HIL, a hole transporting layer (HTL) and then emissive layer (EML) were also formed by spin-coating. The HTL was made by spin-coating a 0.5 wt% solution of the hole transporting material HTL-1 in toluene at 4000 rpm for 60 seconds. The HTL film was baked at 200° C for 30 minutes. After baking, the HTL became an insoluble film.

[0088] The EML was made using Host-1 as the host material and the green-emitting phosphorescent Dopant-1 as the emissive material. To form the EML, a toluene solution containing Host-1 and Dopant-1 (of total 0.75 wt%), with a Host-1: Dopant-1 weight ratio of 88:12, was spin-coated onto the insoluble HTL at 1000 rpm for 60 seconds, and then baked at 100° C for 30 minutes.

[0089] The hole blocking layer (containing the compound HPT), the electron transport layer (containing Alq_3), the electron injection layer (containing LiF), and the aluminum electrode were sequentially vacuum deposited.

[0090] For performance testing, these green-emitting devices were operated under a constant DC current. FIG. 3 shows a plot of luminance intensity versus time for the devices. The lifetime LT_{80} (as measured by the time elapsed for decay of brightness to 80% of the initial level) were 9 h, 143 h, 87 h, and 131 h for the Comparative, HIL1, Comparative HIL2, and Comparative HIL3 devices, respectively. The device with new HIL materials have much longer lifetime than the comparative PEDOT:PSS device.

[0091] Table 3 summarizes the performance of the green-emitting devices. As seen in Table 3, the HIL1 device had similar performance in luminous efficiency (39 cd/A) and lower operating voltage (7.8 V) compared to Comparative device (42 cd/A, 8.1 V) at 4000 cd/m^2. However, Comparative HIL2 and Comparative HIL3 had lower efficiency and

higher voltage than the Comparative device.

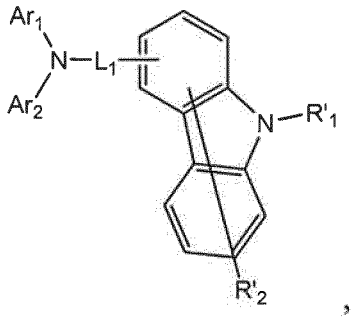
TABLE 3.

	Comparative Device	HIL1 Device	Comparative HIL2 Device	Comparative HIL3 Device
Operating Voltage (V) @ 4000 cd/m^2	8.1	7.8	8.2	8.6
Luminous Efficiency (cd/A) @ 4000 cd/m^2	42	39	20	20
Lifetime LT_{80} (hours) from 4000 cd/m^2	9	143	87	131
Color Coordinate CIE 1931 (x,y)	(0.36, 0.60)	(0.33, 0.62)	(0.33, 0.63)	(0.32, 0.63)

Claims

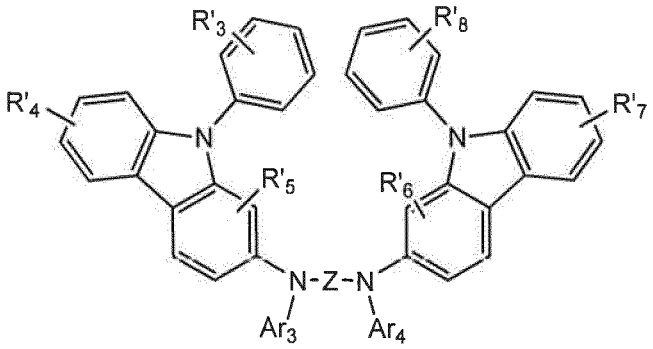
1. A method of fabricating an organic light emitting device, the method comprising:

providing an electrode;
depositing a first organic layer in contact with the electrode by a solution process, wherein the first organic layer comprises a non-crosslinkable organic electron acceptor; and
a non-crosslinkable organic electron donor, wherein the non-crosslinkable organic electron donor has the formula:



,

wherein L_1 represents a substituted or unsubstituted arylene group having 6 to 60 carbon atoms forming the aromatic ring, a substituted or unsubstituted fluorenylene group, or a substituted or unsubstituted heteroarylene group having 5 to 60 atoms forming a ring; Ar_1 and Ar_2 each independently represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic ring or a substituted or unsubstituted heteroaryl group having 5 to 60 atoms forming a ring; R'_1 represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic ring; R'_2 represents a hydrogen atom, a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic ring, a substituted or unsubstituted alkyl group having 1 to 50 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 50 carbon atoms, a substituted or unsubstituted aryloxy group having 6 to 50 atoms forming a ring, a substituted or unsubstituted arylthio group having 5 to 50 atoms forming a ring, a substituted or unsubstituted alkoxycarbonyl group having 2 to 50 carbon atoms, an amino group substituted by a substituted or unsubstituted aryl group having 6 to 50 carbon atoms forming the aromatic ring, a halogen atom, a cyano group, a nitro group, a hydroxyl group or a carboxyl group; with the proviso that neither An nor Ar_2 contains a fluorene structure, and that the number of a carbazole structures in the aromatic amine derivative represented by the formula is 1 or 2;
or
wherein the non-crosslinkable organic electron donor has the formula:



wherein Z is selected from the group consisting of a substituted or unsubstituted C1-C30 alkylene group, a substituted or unsubstituted C2-C30 alkenylene group, a substituted or unsubstituted C6-C30 arylene group, a substituted or unsubstituted C2-C30 heteroarylene group, and a substituted or unsubstituted C2-C30 heterocyclic group; each of R'_3, R'_4, R'_5, R'_6, R'_7, and R'_8 is independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C1-C30 alkyl group, a substituted or unsubstituted C1-C30 alkoxy group, a substituted or unsubstituted C6-C30 aryl group, a substituted or unsubstituted C6-C30 aryloxy group, a substituted or unsubstituted C2-C30 heterocyclic group, a substituted or unsubstituted C6-C30 condensed polycyclic group, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, and, alternatively, two or more adjacent groups among R'_3, R'_4, R'_5, R'_6, R'_7, and R'_8 can be connected to each other to form a saturated or unsaturated carbocycle; and

wherein each of Ar_3 and Ar_4 are independently a substituted or unsubstituted C6-C30 aryl group or a substituted or unsubstituted C2-C30 heteroaryl group; and

heating the first organic layer to form a layer that is insoluble in a non-polar solvent.

2. The method of claim 1, wherein the non-polar solvent is selected from the group consisting of benzene, carbon tetrachloride, cyclohexane, 1,2-dichloroethane, dichloromethane, di-ethyl ether, heptane, hexane, methyl-t-butyl ether, pentane, di-iso-propyl ether, toluene, and xylene.

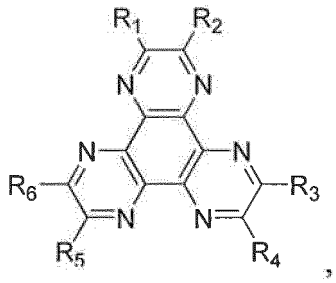
3. The method of claim 1, wherein the non-polar solvent is toluene.

4. The method of claim 1, wherein a second organic layer containing a non-polar solvent is deposited over the first organic layer, and the first organic layer is insoluble to the non-polar solvent in the second organic layer.

5. The method of claim 1, wherein the first organic layer is a hole injection layer.

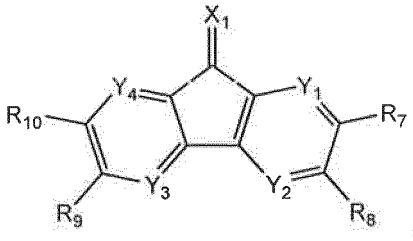
6. The method of claim 1, wherein the second organic layer is a hole transporting layer, a hole blocking layer, an electron transporting layer, an electron injection layer, or an emissive layer.

7. The method of claim 1, wherein the non-crosslinkable organic electron acceptor is selected from the group of compounds having the formulas:

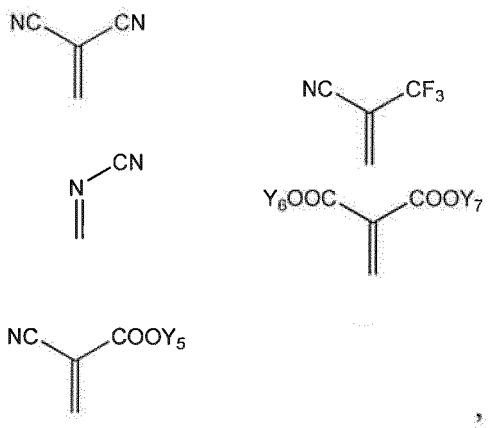


wherein R_1, R_2, R_3, R_4, R_5, and R_6 are independently chosen from the group consisting of hydrogen, halogen, nitrile, nitro, sulfonyl, solfoxide, sulfonamide, sulfonate, trifluoromethyl, ester, amide, straight-chain or branched C1-C12 alkoxy, straight-chain or branched C1-C12 alkyl, aromatic or non-aromatic (substituted or unsubstituted) heterocyclic, substituted or unsubstituted aryl, mono- or di-(substituted or unsubstituted)aryl-amine, and (substituted or unsub-

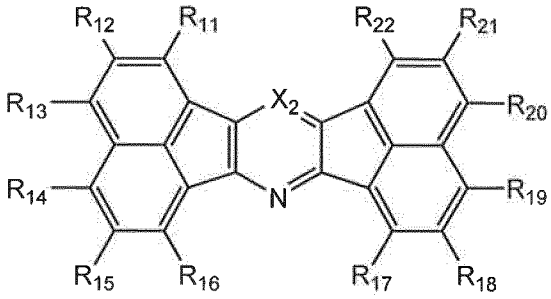
stituted)alkyl-(substituted or unsubstituted)aryl-amine; or where R_1 and R_2, R_3 and R_4, and R_5 and R_6 combine form a ring structure including an aromatic ring, a heteroaromatic ring, or a non-aromatic ring, and each ring is substituted or unsubstituted;



wherein Y_1 to Y_4 are independently a carbon atom or a nitrogen atom, R_7 to R_{10} are independently a hydrogen atom, an alkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted heterocycle, a halogen atom, a fluoroalkyl group or a cyano group, R_7 and R_8, and R_9 and R_{10} are independently bonded to form a substituted or unsubstituted aromatic ring or a substituted or unsubstituted heterocycle, and X_1 is selected from the group consisting of:



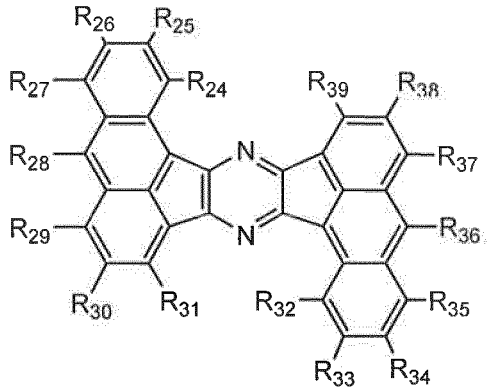
wherein Y_5 to Y_7 are independently a hydrogen atom, a fluoroalkyl group, an alkyl group, an aryl group or a heterocyclic group; and Y_6 and Y_7 may form a ring;



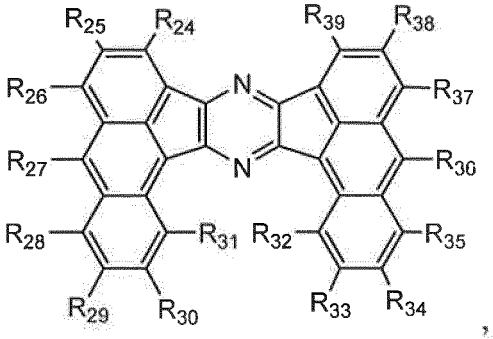
wherein X_2 is

wherein C(R_{23}) or N, R_{11} to R_{23} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has

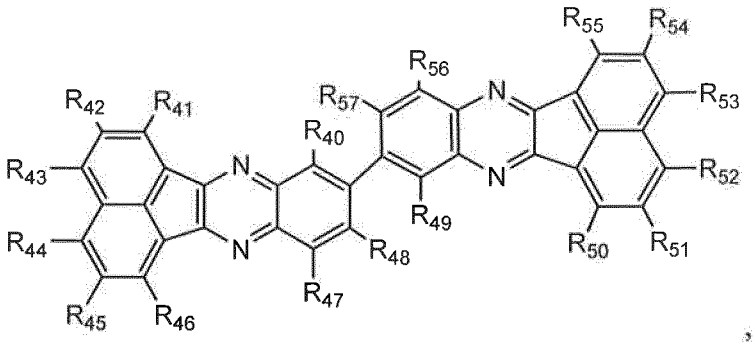
1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{11} to R_{23} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{11} to R_{23}, which are adjacent to one another, may be linked together to form a ring structure;



and

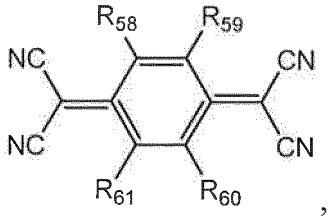


wherein R_{24} to R_{39} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{24} to R_{39} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{24} to R_{39} which are adjacent to one another, may be linked together to form a ring structure;



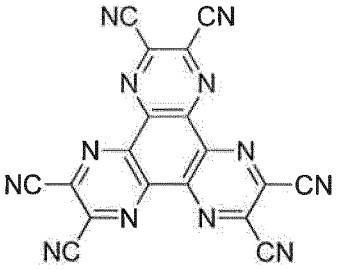
wherein R_{40} to R_{57} each independently represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 30 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 30 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, a trialkylsilyl group wherein the alkyl group has 1 to 20 carbon

atoms and may have a substituent, an aryloxy group wherein the aryl group has 6 to 40 carbon atoms and may have a substituent, a halogen atom, or a cyano group, provided that at least two of R_{40} to R_{57} each represent a cyano group, a trifluoromethyl group or a fluorine atom and that those of R_{40} to R_{57} which are adjacent to one another, may be linked together to form a ring structure; and



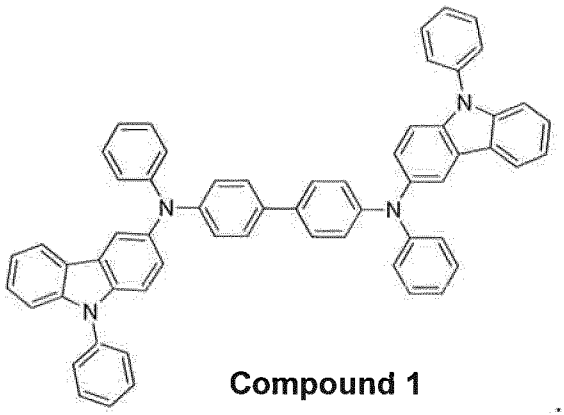
wherein R_{58}-R_{61} independently represents hydrogen, fluorine,or substituents independently selected from nitrile (-CN), nitro (-NO_2), sulfonyl (-SO_2R), sulfoxide (-SOR), trifluoromethyl (-CF_3), ester (-CO-DR), amide (-CONHR or -CO-NRR'), substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or substituted or unsubstituted alkyl, where Rand R' include substituted or unsubstituted alkyl or aryl; or R_{58} and R_{59}, or R_{60} and R_{61}, combine form a ring structure including an aromatic ring, a heteroaromatic ring, or a non-aromatic ring, and each ring is substituted or unsubstituted.

8. The method of claim 1, wherein the non-crosslinkable organic electron acceptor is:



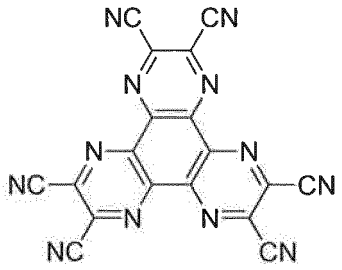
Dopant 1

9. The method of claim 1, wherein the non-crosslinkable organic electron donor is



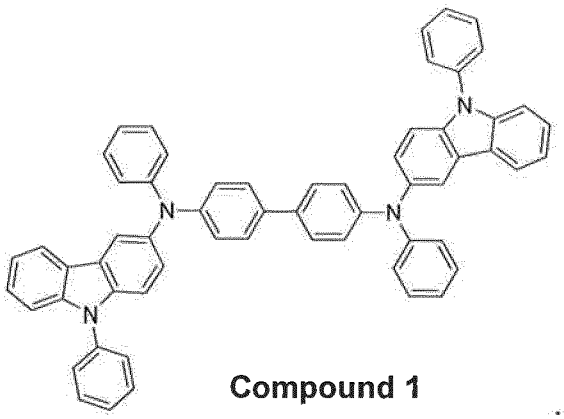
Compound 1

10. The method of claim 1, wherein the non-crosslinkable organic electron acceptor is:



Dopant 1

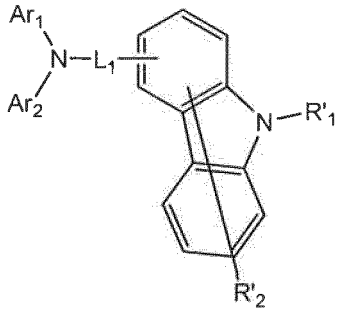
and
wherein the non-crosslinkable organic electron donor is



Compound 1

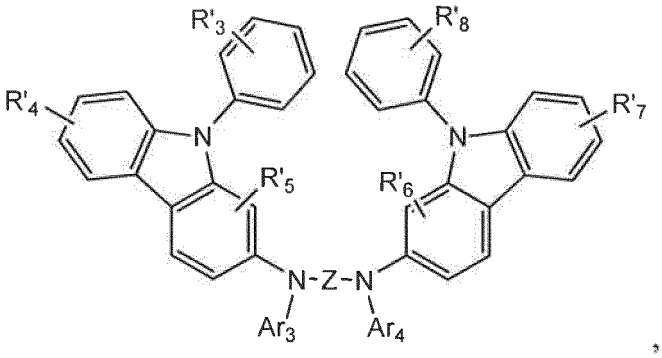
11. A first device comprising an organic light emitting device, further comprising:

an anode;
a cathode; and
a first organic layer disposed between the anode and the cathode, in contact with the anode or the cathode, wherein the first organic layer comprises a non-crosslinkable organic electron acceptor; and
a non-crosslinkable organic electron donor, wherein the non-crosslinkable organic electron donor has the formula:



wherein L_1 represents a substituted or unsubstituted arylene group having 6 to 60 carbon atoms forming the aromatic ring, a substituted or unsubstituted fluorenylene group, or a substituted or unsubstituted heteroarylene group having 5 to 60 atoms forming a ring; Ar_1 and Ar_2 each independently represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic ring or a substituted or unsubstituted heteroaryl group having 5 to 60 atoms forming a ring; R'_1 represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic ring; R'_2 represents a hydrogen atom, a substituted or unsubstituted aryl group having 6 to 60 carbon atoms forming the aromatic ring, a substituted or unsubstituted

alkyl group having 1 to 50 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 50 carbon atoms, a substituted or unsubstituted aryloxy group having 6 to 50 atoms forming a ring, a substituted or unsubstituted arylthio group having 5 to 50 atoms forming a ring, a substituted or unsubstituted alkoxycarbonyl group having 2 to 50 carbon atoms, an amino group substituted by a substituted or unsubstituted aryl group having 6 to 50 carbon atoms forming the aromatic ring, a halogen atom, a cyano group, a nitro group, a hydroxyl group or a carboxyl group; with the proviso that neither Ar_1 nor Ar_2 contains a fluorene structure, and that the number of a carbazole structures in the aromatic amine derivative represented by the formula is 1 or 2;
or
wherein the non-crosslinkable organic electron donor has the formula:

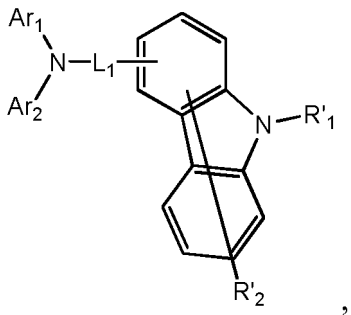


wherein Z is selected from the group consisting of a substituted or unsubstituted C1-C30 alkylene group, a substituted or unsubstituted C2-C30 alkenylene group, a substituted or unsubstituted C6-C30 arylene group, a substituted or unsubstituted C2-C30 heteroarylene group, and a substituted or unsubstituted C2-C30 heterocyclic group; each of R'_3, R'_4, R'_5, R'_6, R'_7, and R'_8 is independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C1-C30 alkyl group, a substituted or unsubstituted C1-C30 alkoxy group, a substituted or unsubstituted C6-C30 aryl group, a substituted or unsubstituted C6-C30 aryloxy group, a substituted or unsubstituted C2-C30 heterocyclic group, a substituted or unsubstituted C6-C30 condensed polycyclic group, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, and, alternatively, two or more adjacent groups among R'_3, R'_4, R'_5, R'_6, R'_7, and R'_8 can be connected to each other to form a saturated or unsaturated carbocycle; and
wherein each of Ar_3 and Ar_4 are independently a substituted or unsubstituted C6-C30 aryl group or a substituted or unsubstituted C2-C30 heteroaryl group; and
wherein the non-crosslinkable organic electron acceptor and the non-crosslinkable organic electron donor form an organic layer insoluble in a non-polar solvent when the composition is heated.

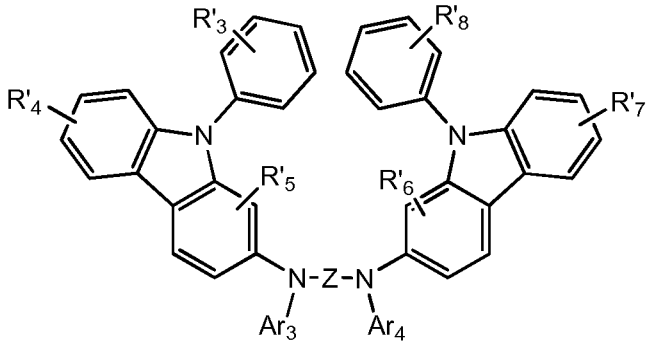
Patentansprüche

1. Ein Verfahren zur Herstellung einer organischen lichtemittierenden Vorrichtung, wobei das Verfahren umfasst:

Bereitstellen einer Elektrode;
Abscheiden einer ersten organischen Schicht in Kontakt mit der Elektrode durch einen Lösungsabscheidungsprozess, wobei die erste organische Schicht einen nicht-vernetzbaren organischen Elektronenakzeptor enthält; und
einen nicht-vernetzbaren organischen Elektronendonor, wobei der nicht-vernetzbare organische Elektronendonor die Formel hat:



wobei L_1 eine substituierte oder unsubstituierte Arylengruppe mit 6 bis 60 Kohlenstoffatomen, die den aromatischen Ring bilden, eine substituierte oder unsubstituierte Fluorenylgruppe, oder eine substituierte oder unsubstituierte Heteroarylengruppe mit 5 bis 60 Atomen, die einen Ring formen, darstellt; Ar_1 und Ar_2 jeweils unabhängig voneinander eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 60 Kohlenstoffatomen, die den aromatischen Ring bilden, oder eine substituierte oder unsubstituierte Heteroarylgruppe mit 5 bis 60 Atomen, die einen Ring bilden, darstellt; R'_1 eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 60 Kohlenstoffatomen, die den aromatischen Ring bilden, darstellt; R'_2 ein Wasserstoffatom, eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 60 Kohlenstoffatomen die den aromatischen Ring bilden, eine substituierte oder unsubstituierte Alkylgruppe mit 1 bis 50 Kohlenstoffatomen, eine substituierte oder unsubstituierte Alkoxygruppe mit 1 bis 50 Kohlenstoffatomen, eine substituierte oder unsubstituierte Aryloxygruppe mit 6 bis 50 Atomen, die einen Ring bilden, eine substituierte oder unsubstituierte Arylthiogruppe mit 5 bis 50 Atomen, die einen Ring bilden, eine substituierte oder unsubstituierte Alkoxycarbonylgruppe mit 2 bis 50 Kohlenstoffatomen, eine Aminogruppe substituiert mit einer substituierten oder unsubstituierten Arylgruppe mit 6 bis 50 Kohlenstoffatomen, die einen aromatischen Ring bilden, ein Halogenatom, eine Cyanogruppe, eine Nitrogruppe, eine Hydroxylgruppe oder eine Carboxylgruppe darstellt; mit der Bedingung dass weder Ar_1 noch Ar_2 eine Fluoren-Struktur enthält, und dass die Anzahl der CarbazolStrukturen in dem durch die Formel dargestellten aromatischen Amin-Derivat 1 oder 2 beträgt;
oder
wobei der nicht-vernetzbare organische Elektronendonor die folgende Formel hat:



wobei Z ausgewählt ist aus der Gruppe bestehend aus einer substituierten oder unsubstituierten C1-C30 Alkylengruppe, einer substituierten oder unsubstituierten C2-C30 Alkenylengruppe, einer substituierten oder unsubstituierten C6-C30 Arylengruppe, einer substituierten oder unsubstituierten C2-C30 Heteroarylengruppe, und einer substituierten oder unsubstituierten C2-C30 heterozyklischen Gruppe; jedes von R'_3, R'_4, R'_5, R'_6, R'_7, und R'_8 unabhängig ausgewählt ist aus der Gruppe bestehend aus einem Wasserstoffatom, einer substituierten oder unsubstituierten C1-C30 Alkylgruppe, einer substituierten oder unsubstituierten C1-C30 Alkoxygruppe, einer substituierten oder unsubstituierten C6-C30 Arylgruppe, einer substituierten oder unsubstituierten C6-C30 Aryloxygruppe, einer substituierten oder unsubstituierten C2-C30 heterozyklischen Gruppe, einer substituierten oder unsubstituierten C6-C30 kondensierten polyzyklischen Gruppe, einer Hydroxylgruppe, einer Cyanogruppe, und einer substituierten oder unsubstituierten Aminogruppe, und, als Alternative, zwei oder mehrere benachbarte Gruppen aus R'_3, R'_4, R'_5, R'_6, R'_7, und R'_8 miteinander verbunden sein können, um einen gesättigten oder ungesättigten Kohlenstoffzyklus zu bilden; und
wobei jedes von Ar_3 und Ar_4 unabhängig eine substituierte oder unsubstituierte C6-C30 Arylgruppe oder eine

substituierte oder unsubstituierte C2-C30 Heteroarylgruppe ist; und
Erhitzen der ersten organischen Schicht, um eine Schicht zu bilden, welche unlöslich in einem unpolaren Lösungsmittel ist.

2. Das Verfahren nach Anspruch 1, wobei das unpolare Lösungsmittel ausgewählt ist aus der Gruppe bestehend aus Benzol, Tetrachlormethan, Cyclohexan, 1,2-Dichlorethan, Dichlormethan, di-Ethylether, Heptan, Hexan, Methyl-t-butylether, Pentan, di-Isopropylether, Toluol, und Xylol.

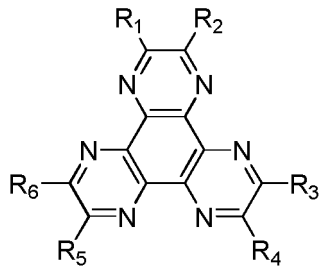
3. Das Verfahren nach Anspruch 1, wobei das unpolare Lösungsmittel Toluol ist.

4. Das Verfahren nach Anspruch 1, wobei eine zweite organische Schicht enthaltend ein unpolares Lösungsmittel auf der ersten organischen Schicht abgeschieden wird, und die erste organische Schicht unlöslich in dem unpolaren Lösungsmittel in der zweiten organischen Schicht ist.

5. Das Verfahren nach Anspruch 1, wobei die erste organische Schicht eine Lochinjektionsschicht ist.

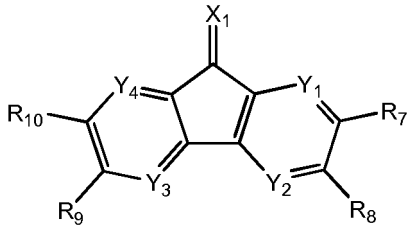
6. Das Verfahren nach Anspruch 1, wobei die zweite organische Schicht eine Lochtransportschicht, eine Lochblockierschicht, eine Elektronentransportschicht, eine Elektroneninjektionsschicht oder eine emittierende Schicht ist.

7. Das Verfahren nach Anspruch 1, wobei der nicht-vernetzbare organische Elektronenakzeptor ausgewählt ist aus der Gruppe von Verbindungen mit den Formeln:



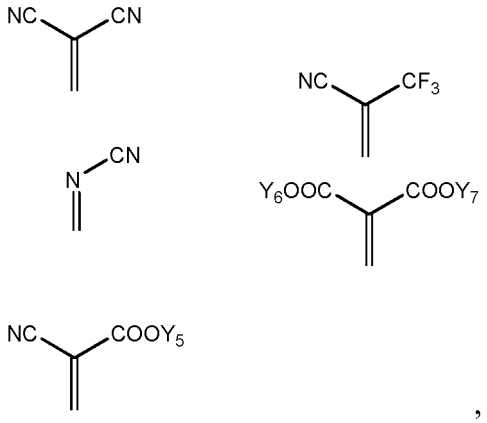
,

wobei R_1, R_2, R_3, R_4, R_5, und R_6 unabhängig ausgewählt sind aus der Gruppe bestehend aus Wasserstoff, Halogen, Nitril, Nitro, Sulfonyl, Sulfoxid, Sulfonamid, Sulfonat, Trifluormethyl, Ester, Amid, unverzweigtem oder verzweigtem C1-C12 Alkoxy, unverzweigtem oder verzweigtem C1-C12 Alkyl, aromatischem oder nicht aromatischem (substituiertem oder nicht substituiertem) Heterozyklus, substituiertem oder nicht substituiertem Aryl, mono- oder di-(substituiertem oder nicht substituiertem)Arylamin, und (substituiertem oder nicht substituiertem)Alkyl-(substituiertem oder nicht substituiertem)Arylamin; oder wobei R_1 und R_2, R_3 und R_4, und R_5 und R_5 sich verbinden um eine Ringstruktur einschließlich einem aromatischen Ring, einem heteroaromatischen Ring, oder einem nicht heteroaromatischen Ring zu bilden, und jeder Ring substituiert oder unsubstituiert ist;



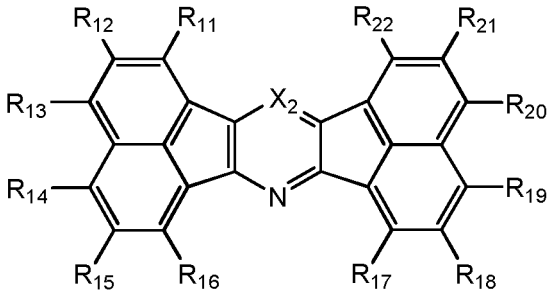
,

wobei Y_1 bis Y_4 unabhängig ein Kohlenstoffatom oder ein Stickstoffatom sind, R_7 bis R_{10} unabhängig ein Wasserstoffatom, eine Alkylgruppe, eine substituierte oder unsubstituierte Arylgruppe, ein substituierter oder unsubstituierter Heterozyklus, ein Halogenatom, eine Fluoralkylgruppe oder eine Cyanogruppe sind, R_7 und R_8, und R_9 und R_{10} unabhängig verbunden sind um einen substituierten oder unsubstituierten aromatischen Ring oder einen substituierten oder unsubstituierten Heterozyklus zu bilden, und X_1 ausgewählt ist aus der Gruppe bestehend aus:



,

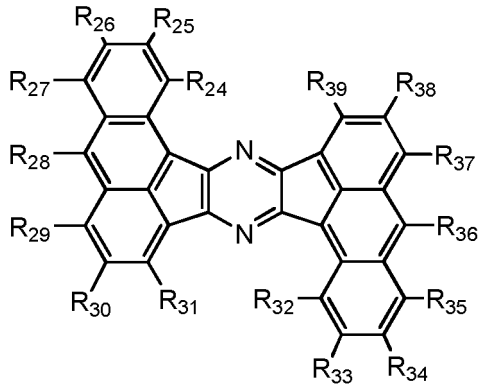
wobei Y_5 bis Y_7 unabhängig ein Wasserstoffatom, eine Fluoralkylgruppe, eine Alkylgruppe, eine Arylgruppe oder eine heterozyklische Gruppe sind; und Y_6 und Y_7 einen Ring bilden können;



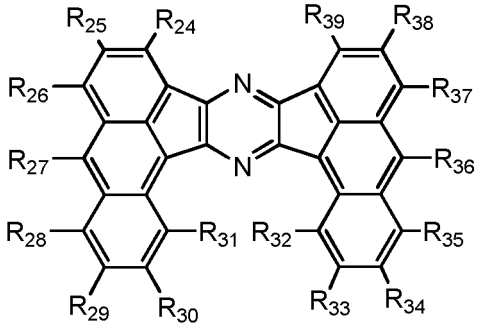
wobei X_2

ist,

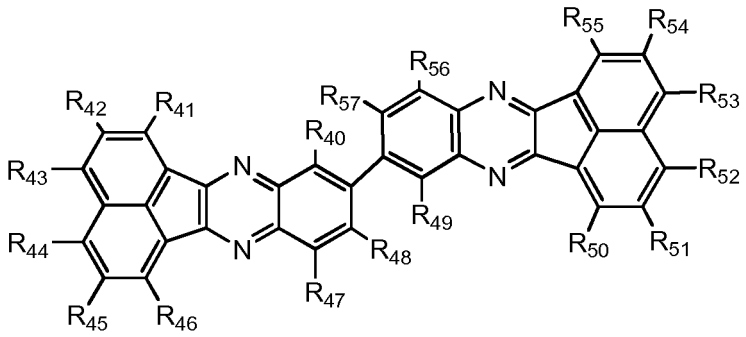
wobei $C(R_{23})$ oder N, R_{11} bis R_{23} jeweils unabhängig ein Wasserstoffatom, eine substituierte oder unsubstituierte Alkylgruppe mit 1 bis 30 Kohlenstoffatomen, eine substituierte oder unsubstituierte Alkoxygruppe mit 1 bis 30 Kohlenstoffatomen, eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 40 Kohlenstoffatomen, eine Trialkylsilylgruppe wobei die Alkylgruppe 1 bis 20 Kohlenstoffatome hat und weitere Substituenten haben kann, eine Aryloxygruppe wobei die Arylgruppe 6 bis 40 Kohlenstoffatome hat und weitere Substituenten haben kann, ein Halogenatom oder eine Cyanogruppe darstellen, vorausgesetzt dass mindestens zwei der R_{11} bis R_{23} jeweils eine Cyanogruppe, eine Trifluormethylgruppe oder ein Fluoratom darstellen und dass diejenigen R_{11} bis R_{23}, welche benachbart zueinander sind, verknüpft sein können, um eine Ringstruktur zu bilden;



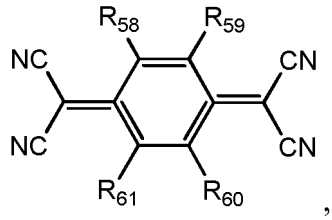
und



wobei R_{24} bis R_{39} jeweils unabhängig ein Wasserstoffatom, eine substituierte oder unsubstituierte Alkylgruppe mit 1 bis 30 Kohlenstoffatomen, eine substituierte oder unsubstituierte Alkoxygruppe mit 1 bis 30 Kohlenstoffatomen, eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 40 Kohlenstoffatomen, eine Trialkylsilylgruppe wobei die Alkylgruppe 1 bis 20 Kohlenstoffatome hat und einen Substituenten haben kann, eine Aryloxygruppe wobei die Arylgruppe 6 bis 40 Kohlenstoffatome hat und einen Substituenten haben kann, ein Halogenatom, oder eine Cyanogruppe darstellen, vorausgesetzt, dass mindestens zwei von R_{24} bis R_{39} jeweils eine Cyanogruppe, eine Trifluormethylgruppe oder ein Fluoratom darstellen und dass diejenigen R_{24} bis R_{39} welche benachbart zueinander sind, verknüpft sein können, um eine Ringstruktur zu bilden;



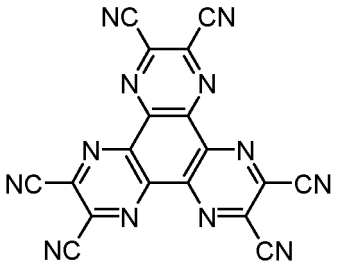
wobei R_{40} bis R_{57} jeweils unabhängig voneinander ein Wasserstoffatom, eine substituierte oder unsubstituierte Alkylgruppe mit 1 bis 30 Kohlenstoffatomen, eine substituierte oder unsubstituierte Alkoxygruppe mit 1 bis 30 Kohlenstoffatomen, eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 40 Kohlenstoffatomen, eine Trialkylsilylgruppe wobei die Alkylgruppe 1 bis 20 Kohlenstoffatome hat und einen Substituenten haben kann, eine Aryloxygruppe wobei die Arylgruppe 6 bis 40 Kohlenstoffatome hat und einen Substituenten haben kann, ein Halogenatom, oder eine Cyanogruppe darstellen, vorausgesetzt, dass mindestens zwei von R_{40} bis R_{57} jeweils eine Cyanogruppe, eine Trifluormethylgruppe oder ein Fluoratom darstellen und dass diejenigen R_{40} bis R_{57} welche benachbart zueinander sind, verknüpft sein können um eine Ringstruktur zu bilden; und



wobei R_{58}-R_{61} unabhängig Wasserstoff, Fluor oder Substituenten unabhängig ausgewählt aus Nitril (-CN), Nitro (-NO_2), Sulfonyl (-SO_2R), Sulfoxid (-SOR), Trifluormethyl (-CF_3), Ester (-CO-DR), Amid (-CONHR oder -CO-NRR'), substituiertes oder unsubstituiertes Aryl, substituiertes oder unsubstituiertes Heteroaryl, oder substituiertes oder unsubstituiertes Alkyl darstellen, wobei R und R' substituiertes oder unsubstituiertes Alkyl oder Aryl umfassen; oder

R_{58} und R_{59}, oder R_{60} und R_{61} sich verbinden, um eine Ringstruktur zu bilden einschließlich eines aromatischen Rings, eines heteroaromatischen Rings, oder eines nicht-aromatischen Rings, und jeder Ring substituiert oder unsubstituiert ist.

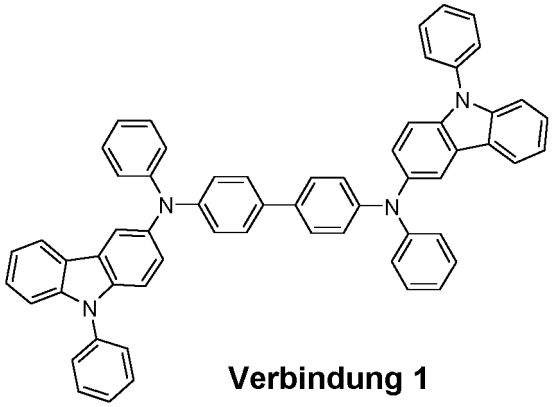
8. Das Verfahren nach Anspruch 1, wobei der nicht-vernetzbare organische Elektronenakzeptor



Dotierstoff 1

ist.

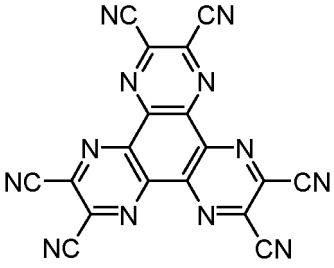
9. Das Verfahren nach Anspruch 1, wobei der nicht-vernetzbare organische Elektronendonor



Verbindung 1

ist.

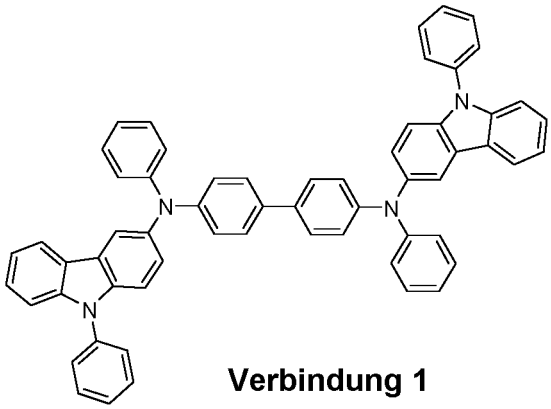
10. Das Verfahren nach Anspruch 1, wobei der nicht-vernetzbare organische Elektronenakzeptor:



Dotierstoff 1 ist,

und

wobei der nicht-vernetzbare organische Elektronendonor

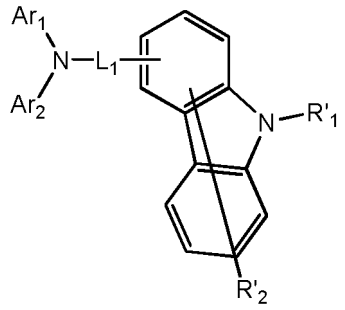


Verbindung 1

ist.

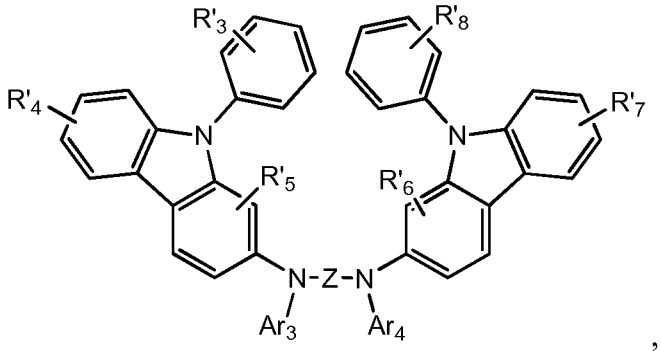
11. Eine erste Vorrichtung umfassend eine organische lichtemittierende Vorrichtung, weiterhin umfassend:

eine Anode;
eine Kathode; und
eine erste organische Schicht angeordnet zwischen der Anode und der Kathode, in Kontakt mit der Anode und der Kathode,
wobei die erste organische Schicht einen nicht-vernetzbaren organischen Elektronenakzeptor; und
einen nicht-vernetzbaren organischen Elektronendonor enthält, wobei der nicht-vernetzbare organische Elektronendonor die Formel hat:



,

wobei L_1 eine substituierte oder unsubstituierte Arylengruppe mit 6 bis 60 Kohlenstoffatomen, die einen aromatischen Ring bilden, eine substituierte oder unsubstituierte Fluorenylgruppe, oder eine substituierte oder unsubstituierte Heteroarylengruppe mit 5 bis 60 Atomen, die einen Ring bilden, darstellt; Ar_1 und Ar_2 jeweils unabhängig eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 60 Kohlenstoffatomen, die den aromatischen Ring bilden, oder eine substituierte oder unsubstituierte Heteroarylgruppe mit 5 bis 60 Atomen, die einen Ring bilden, darstellen; R'_1 eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 60 Kohlenstoffatomen, die den aromatischen Ring bilden, darstellt; R'_2 ein Wasserstoffatom, eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 60 Kohlenstoffatomen, die den aromatischen Ring bilden, eine substituierte oder unsubstituierte Alkylgruppe mit 1 bis 50 Kohlenstoffatomen, eine substituierte oder unsubstituierte Alkoxygruppe mit 1 bis 50 Kohlenstoffatomen, eine substituierte oder unsubstituierte Aryloxygruppe mit 6 bis 50 Atomen, die einen Ring bilden, eine substituierte oder unsubstituierte Arylthiogruppe mit 5 bis 50 Atomen, die einen Ring bilden, eine substituierte oder unsubstituierte Alkoxycarbonylgruppe mit 2 bis 50 Kohlenstoffatomen, eine Aminogruppe substituiert mit einer substituierten oder unsubstituierten Arylgruppe mit 6 bis 50 Kohlenstoffatomen die den aromatischen Ring bilden, ein Halogenatom, eine Cyanogruppe, eine Nitrogruppe, eine Hydroxylgruppe oder eine Carboxylgruppe darstellt; unter der Voraussetzung dass weder Ar_1 noch Ar_2 eine Fluorenstruktur enthält, und dass die Anzahl an Carbazolstrukturen in dem durch die Formel dargestellten aromatischen Amin-Derivativ 1 oder 2 ist;
oder
wobei der nicht-vernetzbare organische Elektronendonor die folgende Formel hat:

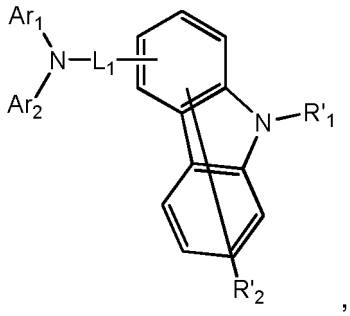


wobei Z ausgewählt ist aus der Gruppe bestehend aus einer substituierten oder unsubstituierten C1-C30 Alkylengruppe, einer substituierten oder unsubstituierten C2-C30 Alkenylengruppe, einer substituierten oder unsubstituierten C6-C30 Arylengruppe, einer substituierten oder unsubstituierten C2-C30 Heteroarylengruppe, und einer substituierten oder unsubstituierten C2-C30 heterozyklischen Gruppe; jedes von R'_3, R'_4, R'_5, R'_6, R'_7, und R'_8 unabhängig ausgewählt ist aus der Gruppe bestehend aus einem Wasserstoffatom, einer substituierten oder unsubstituierten C1-C30 Alkylgruppe, einer substituierten oder unsubstituierten C1-C30 Alkoxygruppe, einer substituierten oder unsubstituierten C6-C30 Arylgruppe, einer substituierten oder unsubstituierten C6-C30 Aryloxygruppe, einer substituierten oder unsubstituierten C2-C30 heterozyklischen Gruppe, einer substituierten oder unsubstituierten C6-C30 kondensierten polyzyklischen Gruppe, einer Hydroxylgruppe, einer Cyanogruppe, und einer substituierten oder unsubstituierten Aminogruppe, und, als Alternative, zwei oder mehrere benachbarte Gruppen aus R'_3, R'_4, R'_5, R'_6, R'_7, und R'_8 miteinander verbunden sein können, um einen gesättigten oder ungesättigten Kohlenstoffzyklus zu bilden; und
wobei jedes von Ar_3 und Ar_4 unabhängig eine substituierte oder unsubstituierte C6-C30 Arylgruppe oder eine substituierte oder unsubstituierte C2-C30 Heteroarylgruppe ist; und
wobei der nicht-vernetzbare organische Elektronenakzeptor und der nicht-vernetzbare organische Elektronendonor eine organische Schicht bilden, die unlöslich in einem unpolaren Lösungsmittel ist, wenn die Zusammensetzung erhitzt wird.

Revendications

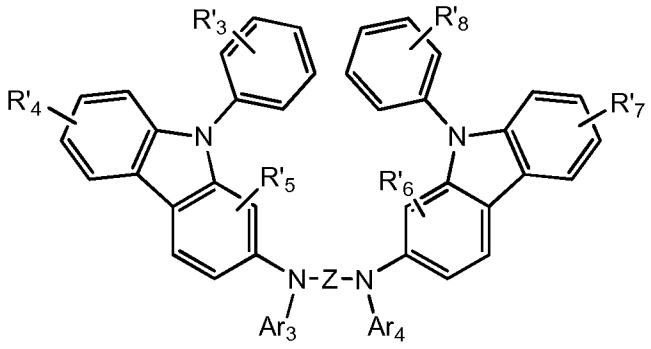
1. Procédé de fabrication d'un dispositif électroluminescent organique, le procédé comprenant :

se procurer une électrode ;
déposer une première couche organique en contact avec l'électrode par un procédé en solution, où la première couche organique comprend un accepteur d'électrons organique non réticulable ; et
un donneur d'électrons organique non réticulable, où le donneur d'électrons organique non réticulable a la formule :



où L_1 représente un groupe arylène substitué ou non substitué ayant de 6 à 60 atomes de carbone formant le cycle aromatique, un groupe fluorénylène substitué ou non substitué, ou un groupe hétéroarylène substitué ou non substitué ayant de 5 à 60 atomes formant un cycle ; Ar_1 et Ar_2 représentent chacun indépendamment un groupe aryle substitué ou non substitué ayant de 6 à 60 atomes de carbone formant le cycle aromatique ou un

groupe hétéroaryle substitué ou non substitué ayant de 5 à 60 atomes formant un cycle ; R'_1 représente un groupe aryle substitué ou non substitué ayant de 6 à 60 atomes de carbone formant le cycle aromatique ; R'_2 représente un atome d'hydrogène, un groupe aryle substitué ou non substitué ayant de 6 à 60 atomes de carbone formant le cycle aromatique, un groupe alkyle substitué ou non substitué ayant de 1 à 50 atomes de carbone, un groupe alcoxy substitué ou non substitué ayant de 1 à 50 atomes de carbone, un groupe aryloxy substitué ou non substitué ayant de 6 à 50 atomes formant un cycle, un groupe arylthio substitué ou non substitué ayant de 5 à 50 atomes formant un cycle, un groupe alcoxycarbonyle substitué ou non substitué ayant de 2 à 50 atomes de carbone, un groupe amino substitué par un groupe aryle substitué ou non substitué ayant de 6 à 50 atomes de carbone formant le cycle aromatique, un atome d'halogène, un groupe cyano, un groupe nitro, un groupe hydroxyle ou un groupe carboxyle ; à la condition que ni Ar_1 ni Ar_2 ne contienne une structure de fluorène, et que le nombre de structures carbazole dans le dérivé amine aromatique représenté par la formule soit 1 ou 2 ;
ou
où le donneur d'électrons organique non réticulable a la formule :



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où Z est choisi dans le groupe constitué par un groupe alkylène en C1-C30 substitué ou non substitué, un groupe alcénylène en C2-C30 substitué ou non substitué, un groupe arylène en C6-C30 substitué ou non substitué, un groupe hétéroarylène en C2-C30 substitué ou non substitué, et un groupe hétérocyclique en C2-C30 substitué ou non substitué ; chacun parmi R'_3, R'_4, R'_5, R'_6, R'_7, et R'_8 est indépendamment choisi dans le groupe constitué par un atome d'hydrogène, un groupe alkyle en C1-C30 substitué ou non substitué, un groupe alcoxy en C1-C30 substitué ou non substitué, un groupe aryle en C6-C30 substitué ou non substitué, un groupe aryloxy en C6-C30 substitué ou non substitué, un groupe hétérocyclique en C2-C30 substitué ou non substitué, un groupe polycyclique condensé en C6-C30 substitué ou non substitué, un groupe hydroxy, un groupe cyano, et un groupe amino substitué ou non substitué, et, en variante, deux groupes adjacents ou plus parmi R'_3, R'_4, R'_5, R'_6, R'_7, et R'_8 peuvent être connectés les uns aux autres pour former un carbocycle saturé ou insaturé ; et
où chacun parmi Ar_3 et Ar_4 est indépendamment un groupe aryle en C6-C30 substitué ou non substitué ou un groupe hétéroaryle en C2-C30 substitué ou non substitué ; et
chauffer la première couche organique pour former une couche qui est insoluble dans un solvant non polaire.

2. Procédé selon la revendication 1, où le solvant non polaire est choisi dans le groupe constitué par le benzène, le tétrachlorure de carbone, le cyclohexane, le 1,2-dichloroéthane, le dichlorométhane, le di-éthyl éther, l'heptane, l'hexane, le méthyl-t-butyl éther, le pentane, le di-iso-propyl éther, le toluène, et le xylène.

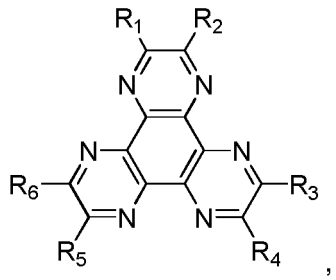
3. Procédé selon la revendication 1, où le solvant non polaire est le toluène.

4. Procédé selon la revendication 1, où une seconde couche organique contenant un solvant non polaire est déposée sur la première couche organique, et la première couche organique est insoluble vis-à-vis du solvant non polaire dans la seconde couche organique.

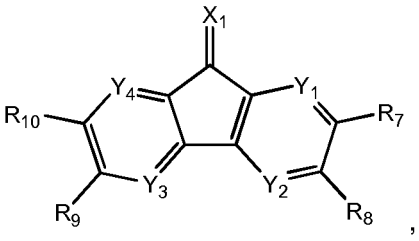
5. Procédé selon la revendication 1, où la première couche organique est une couche d'injection de trous.

6. Procédé selon la revendication 1, où la seconde couche organique est une couche de transport de trous, une couche de blocage de trous, une couche de transport d'électrons, une couche d'injection d'électrons, ou une couche émissive.

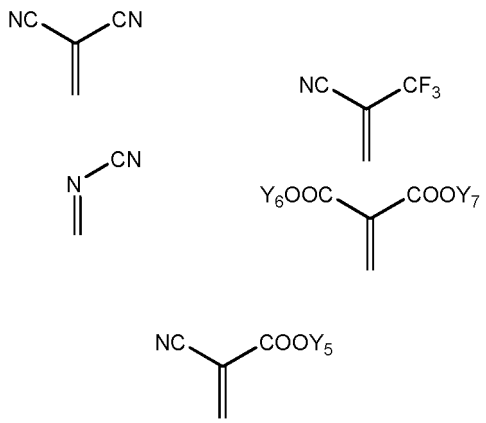
7. Procédé selon la revendication 1, où l'accepteur d'électrons organique non réticulable est choisi dans le groupe des composés ayant les formules :



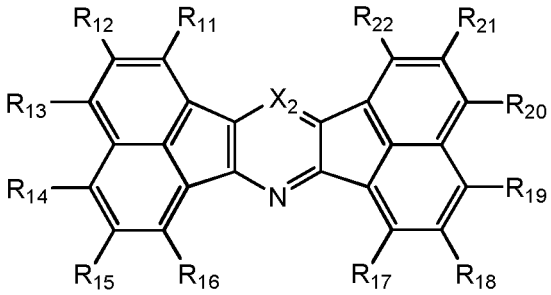
où R_1, R_2, R_3, R_4, R_5, et R_6 sont indépendamment choisis dans le groupe constitué par hydrogène, halogène, nitrile, nitro, sulfonyle, sulfoxide, sulfonamide, sulfonate, trifluorométhyle, ester, amide, alcoxy en C1-C12 à chaîne droite ou ramifié, alkyle en C1-C12 à chaîne droite ou ramifié, hétérocyclique aromatique ou non aromatique (substitué ou non substitué), aryle substitué ou non substitué, mono- ou di-aryl(substitué ou non substitué)-amine, et alkyl(substitué ou non substitué)-aryl(substitué ou non substitué)-amine ; ou bien où R_1 et R_2, R_3 et R_4, et R_5 et R_6 se combinent pour former une structure de cycle comprenant un cycle aromatique, un cycle hétéroaromatique, ou un cycle non aromatique, et chaque cycle est substitué ou non substitué ;



où Y_1 à Y_4 sont indépendamment un atome de carbone ou un atome d'azote, R_7 à R_{10} sont indépendamment un atome d'hydrogène, un groupe alkyle, un groupe aryle substitué ou non substitué, un hétérocycle substitué ou non substitué, un atome d'halogène, un groupe fluoroalkyle ou un groupe cyano, R_7 et R_8, et R_9 et R_{10} sont indépendamment liés pour former un cycle aromatique substitué ou non substitué ou un hétérocycle substitué ou non substitué, et X_1 est choisi dans le groupe constitué par :

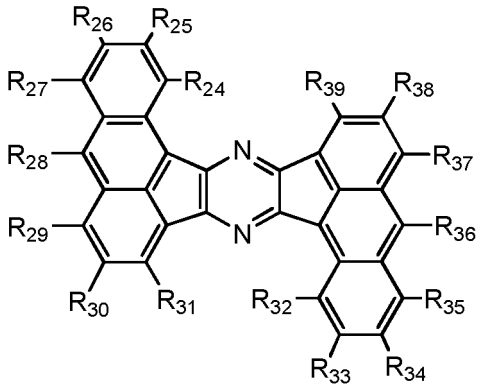


où Y_5 à Y_7 sont indépendamment un atome d'hydrogène, un groupe fluoroalkyle, un groupe alkyle, un groupe aryle ou un groupe hétérocyclique ; et Y_6 et Y_7 peuvent former un cycle ;

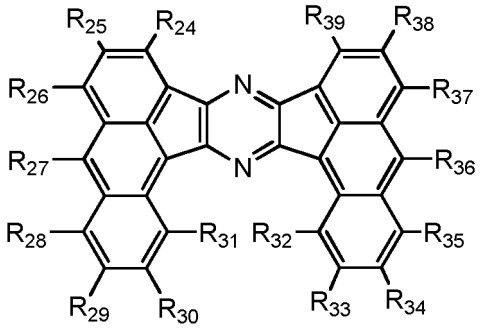


où X_2 est

où $C(R_{23})$ ou N, R_{11} à R_{23} représentent chacun indépendamment un atome d'hydrogène, un groupe alkyle substitué ou non substitué ayant de 1 à 30 atomes de carbone, un groupe alcoxy substitué ou non substitué ayant de 1 à 30 atomes de carbone, un groupe aryle substitué ou non substitué ayant de 6 à 40 atomes de carbone, un groupe trialkylsilyle où le groupe alkyle a de 1 à 20 atomes de carbone et peut avoir un substituant, un groupe aryloxy où le groupe aryle a de 6 à 40 atomes de carbone et peut avoir un substituant, un atome d'halogène, ou un groupe cyano, à condition qu'au moins deux parmi R_{11} à R_{23} représentent chacun un groupe cyano, un groupe trifluorométhyle ou un atome de fluor et que ceux parmi R_{11} à R_{23}, qui sont adjacents les uns aux autres, puissent être liés ensemble pour former une structure de cycle ;



et



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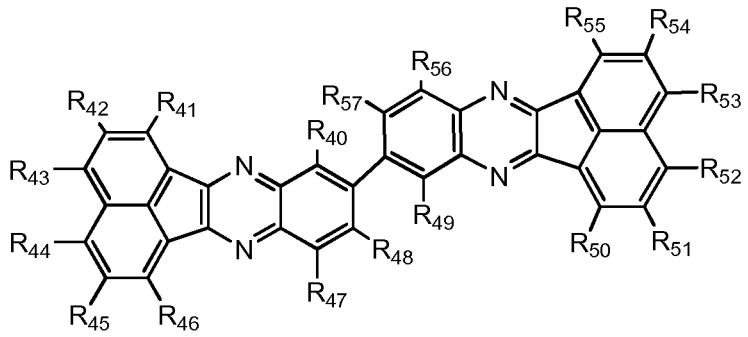
où R_{24} à R_{39} représentent chacun indépendamment un atome d'hydrogène, un groupe alkyle substitué ou non substitué ayant de 1 à 30 atomes de carbone, un groupe alcoxy substitué ou non substitué ayant de 1 à 30 atomes de carbone, un groupe aryle substitué ou non substitué ayant de 6 à 40 atomes de carbone, un groupe trialkylsilyle

où le groupe alkyle a de 1 à 20 atomes de carbone et peut avoir un substituant, un groupe aryloxy où le groupe aryle a de 6 à 40 atomes de carbone et peut avoir un substituant, un atome d'halogène, ou un groupe cyano, à condition qu'au moins deux parmi R_{24} à R_{39} représentent chacun un groupe cyano, un groupe trifluorométhyle ou un atome de fluor et que ceux parmi R_{24} à R_{39} qui sont adjacents les uns aux autres, puissent être liés ensemble pour former une structure de cycle ;



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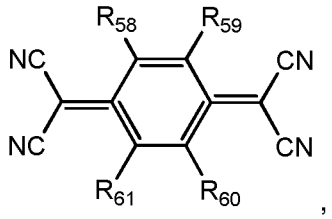
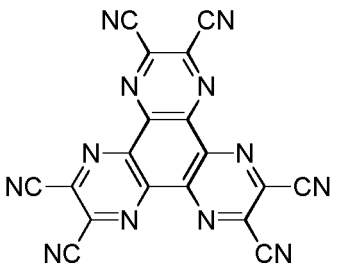
où R_{40} à R_{57} représentent chacun indépendamment un atome d'hydrogène, un groupe alkyle substitué ou non substitué ayant de 1 à 30 atomes de carbone, un groupe alcoxy substitué ou non substitué ayant de 1 à 30 atomes de carbone, un groupe aryle substitué ou non substitué ayant de 6 à 40 atomes de carbone, un groupe trialkylsilyle où le groupe alkyle a de 1 à 20 atomes de carbone et peut avoir un substituant, un groupe aryloxy où le groupe aryle a de 6 à 40 atomes de carbone et peut avoir un substituant, un atome d'halogène, ou un groupe cyano, à condition qu'au moins deux parmi R_{40} à R_{57} représentent chacun un groupe cyano, un groupe trifluorométhyle ou un atome de fluor et que ceux parmi R_{40} à R_{57} qui sont adjacents les uns aux autres, puissent être liés ensemble pour former une structure de cycle ; et



,

où R_{58}-R_{61} représentent indépendamment hydrogène, fluor, ou des substituants indépendamment choisis parmi nitrile (-CN), nitro (-NO_2), (sulfonyle -SO_2R), sulfoxyde (-SOR), trifluorométhyle (-CF_3), ester (-CO-DR), amide (-CONHR ou -CO-NRR'), aryle substitué ou non substitué, hétéroaryle substitué ou non substitué, ou alkyle substitué ou non substitué, où R et R' comprennent alkyle ou aryle substitué ou non substitué ; ou R_{58} et R_{59}, ou R_{60} et R_{61}, se combinent pour former une structure de cycle comprenant un cycle aromatique, un cycle hétéroaromatique, ou un cycle non aromatique, et chaque cycle est substitué ou non substitué.

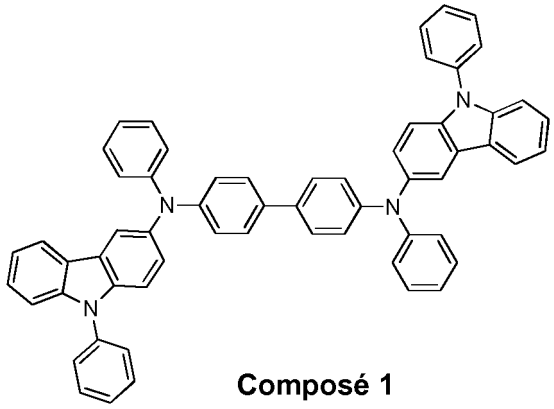
8. Procédé selon la revendication 1, où l'accepteur d'électrons organique non réticulable est :



Dopant 1

.

9. Procédé selon la revendication 1, où le donneur d'électrons organique non réticulable est



Composé 1

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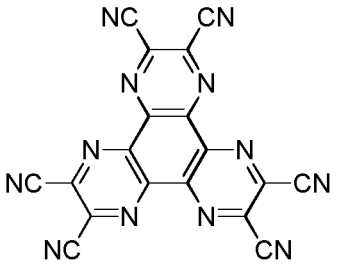
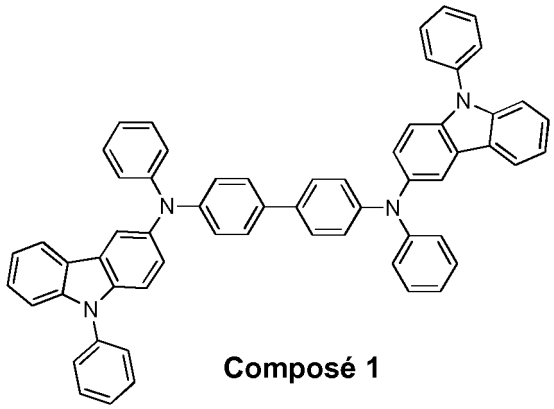
10. Procédé selon la revendication 1, où l'accepteur d'électrons organique non réticulable est :



Dopant 1

,

et
où le donneur d'électrons organique non réticulable est



Composé 1

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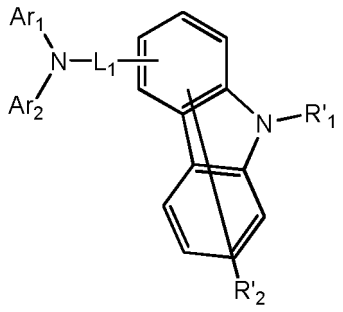
11. Premier dispositif comprenant un dispositif électroluminescent organique, comprenant en outre :

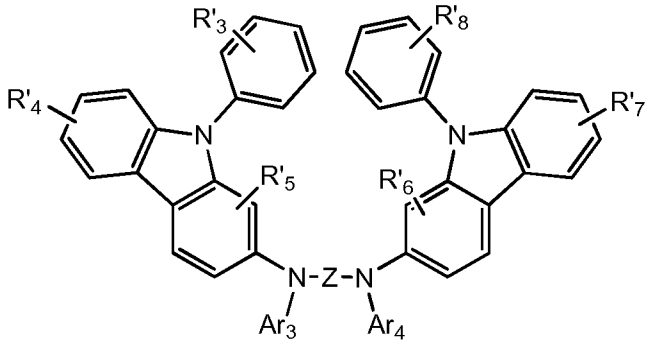
une anode ;
une cathode ; et
une première couche organique disposée entre l'anode et la cathode, en contact avec l'anode ou la cathode, où la première couche organique comprend un accepteur d'électrons organique non réticulable ; et
un donneur d'électrons organique non réticulable, où le donneur d'électrons organique non réticulable a la formule :



où L_1 représente un groupe arylène substitué ou non substitué ayant de 6 à 60 atomes de carbone formant le cycle aromatique, un groupe fluorénylène substitué ou non substitué, ou un groupe hétéroarylène substitué ou non substitué ayant de 5 à 60 atomes formant un cycle ; Ar_1 et Ar_2 représentent chacun indépendamment un groupe aryle substitué ou non substitué ayant de 6 à 60 atomes de carbone formant le cycle aromatique ou un groupe hétéroaryle substitué ou non substitué ayant de 5 à 60 atomes formant un cycle ; R'_1 représente un groupe aryle substitué ou non substitué ayant de 6 à 60 atomes de carbone formant le cycle aromatique ; R'_2 représente un atome d'hydrogène, un groupe aryle substitué ou non substitué ayant de 6 à 60 atomes de carbone formant le cycle aromatique, un groupe alkyle substitué ou non substitué ayant de 1 à 50 atomes de carbone, un groupe alcoxy substitué ou non substitué ayant de 1 à 50 atomes de carbone, un groupe aryloxy substitué ou non substitué ayant de 6 à 50 atomes formant un cycle, un groupe arylthio substitué ou non substitué ayant de 5 à 50 atomes formant un cycle, un groupe alcoxycarbonyle substitué ou non substitué ayant de 2 à 50 atomes de carbone, un groupe amino substitué par un groupe aryle substitué ou non substitué ayant de 6 à 50 atomes de carbone formant le cycle aromatique, un atome d'halogène, un groupe cyano, un groupe nitro, un groupe hydroxyle ou un groupe carboxyle ; à la condition que ni Ar_1 ni Ar_2 ne contienne une structure de fluorène, et que le nombre de structures carbazole dans le dérivé amine aromatique représenté par la formule soit 1 ou 2 ;

ou

où le donneur d'électrons organique non réticulable a la formule :



où Z est choisi dans le groupe constitué par un groupe alkylène en C1-C30 substitué ou non substitué, un groupe alcénylène en C2-C30 substitué ou non substitué, un groupe arylène en C6-C30 substitué ou non substitué, un groupe hétéroarylène en C2-C30 substitué ou non substitué, et un groupe hétérocyclique en C2-C30 substitué ou non substitué ; chacun parmi R'_3, R'_4, R'_5, R'_6, R'_7, et R'_8 est indépendamment choisi dans le groupe constitué par un atome d'hydrogène, un groupe alkyle en C1-C30 substitué ou non substitué, un groupe alcoxy en C1-C30 substitué ou non substitué, un groupe aryle en C6-C30 substitué ou non substitué, un groupe aryloxy en C6-C30 substitué ou non substitué, un groupe hétérocyclique en C2-C30 substitué ou non substitué, un groupe polycyclique condensé en C6-C30 substitué ou non substitué, un groupe hydroxy, un groupe cyano, et un groupe amino substitué ou non substitué, et, en variante, deux groupes adjacents ou plus parmi R'_3, R'_4, R'_5, R'_6, R'_7, et R'_8 peuvent être connectés les uns aux autres pour former un carbocycle saturé ou insaturé ; et

où chacun parmi Ar_3 et Ar_4 est indépendamment un groupe aryle en C6-C30 substitué ou non substitué ou un groupe hétéroaryle en C2-C30 substitué ou non substitué ; et

où l'accepteur d'électrons organique non réticulable et le donneur d'électrons organique non réticulable forment

une couche organique insoluble dans un solvant non polaire lorsque la composition est chauffée.

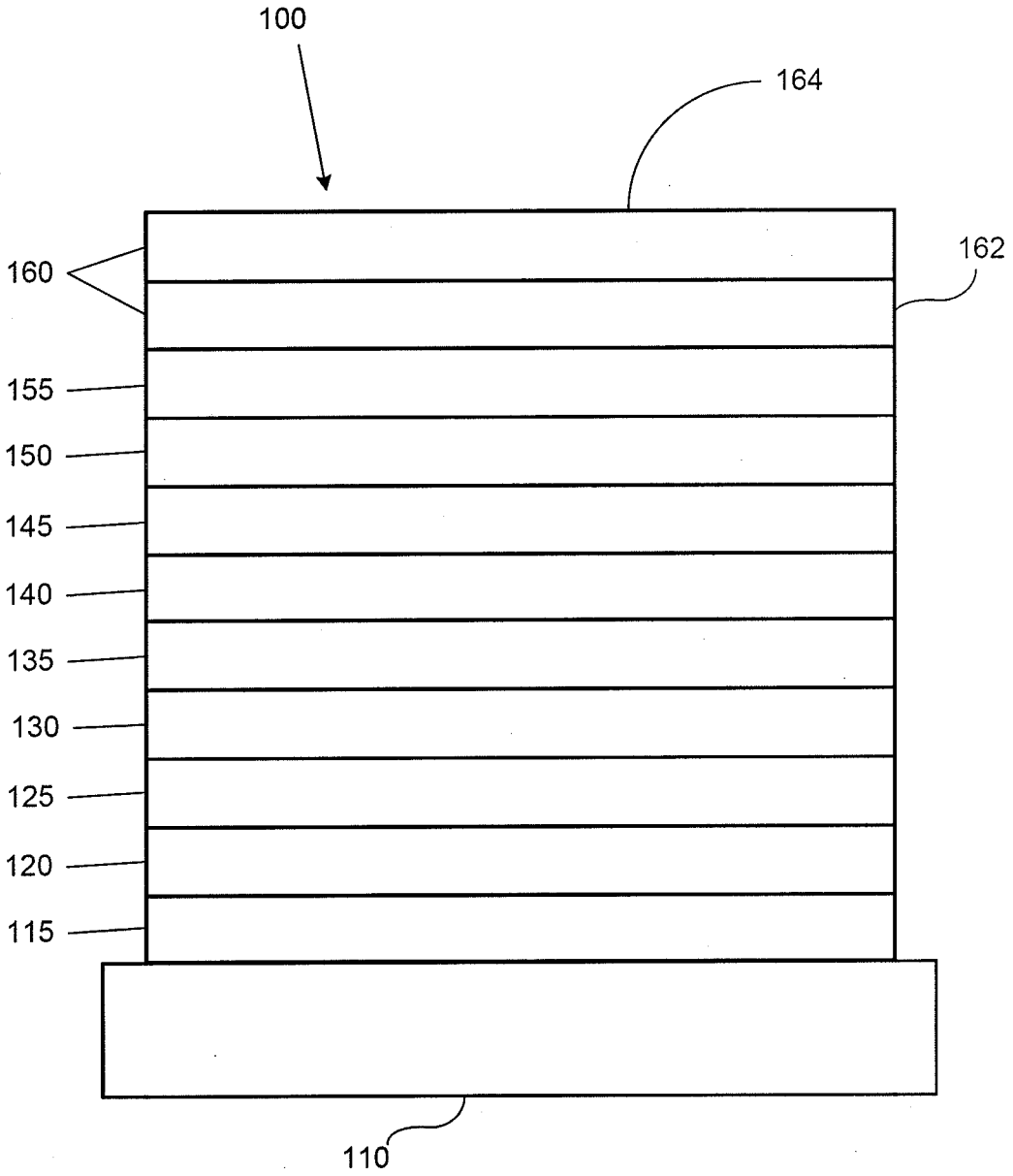


FIGURE 1

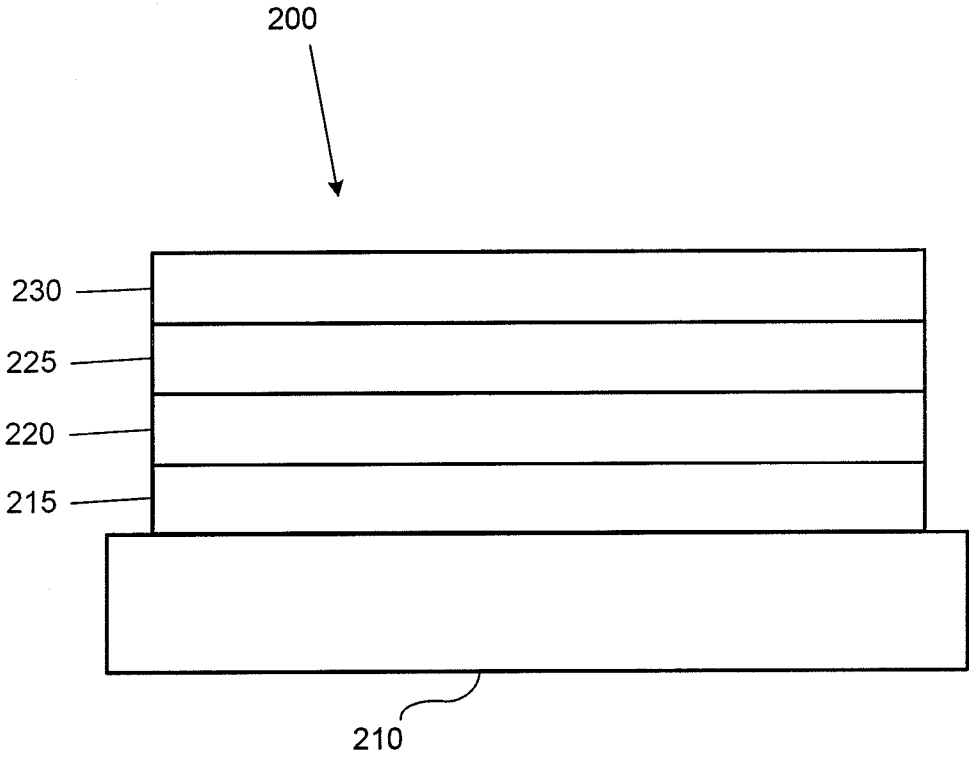


FIGURE 2

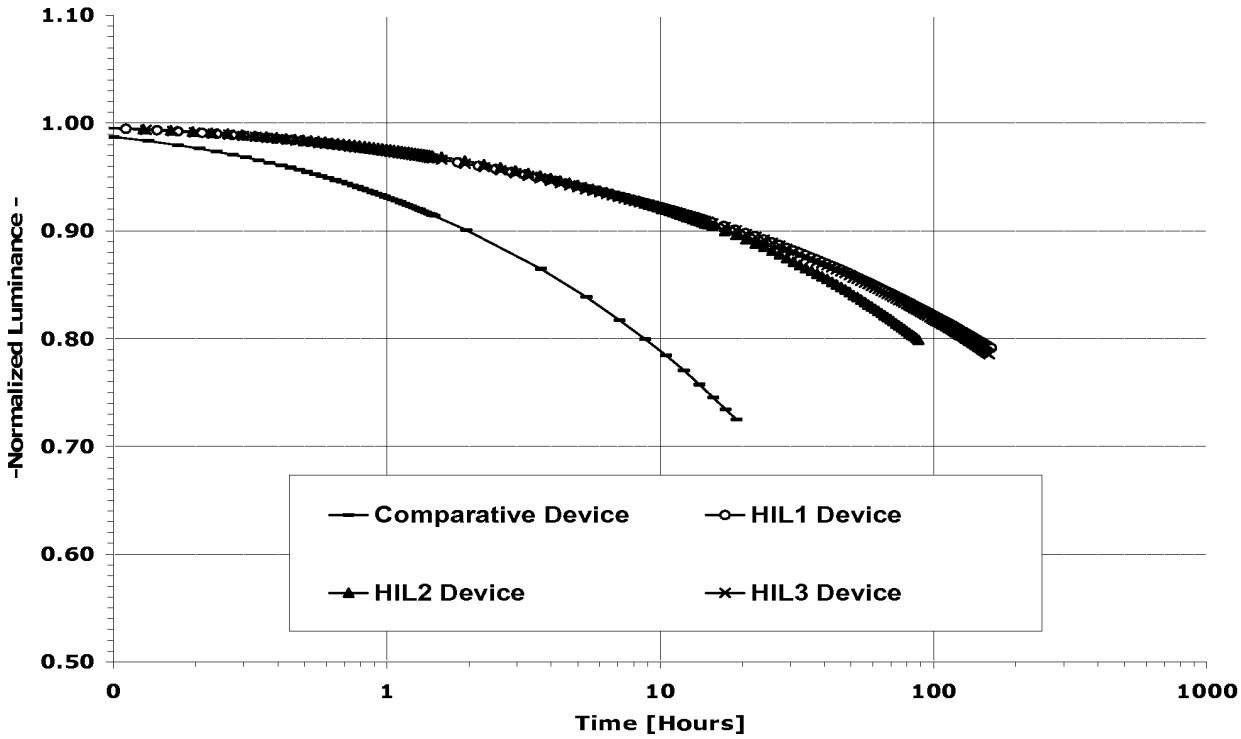

1.10
1.00
0.90
0.80
0.70
0.60
0.50
-Normalized Luminance -
0
1
10
100
1000
Time [Hours]
Comparative Device
HIL1 Device
HIL2 Device
HIL3 Device

FIGURE 3

REFERENCES CITED IN THE DESCRIPTION

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摘要(译)

提供了制造溶液处理的OLED的方法。该方法包括沉积包含有机电子受体和有机电子给体的混合物的有机层，以形成不溶于非极性溶剂的层。包含有机层的器件可以表现出改善的寿命并且具有较低的工作电压，同时保持良好的发光效率。