(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 753 047 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
12.04.2017 Bulletin 2017/15

(21) Application number: **06015829.2**

(22) Date of filing: **28.07.2006**

(51) Int Cl.:
H01L 51/50 *(2006.01)* ***H01L 51/54*** *(2006.01)*
H01L 51/56 *(2006.01)*

(54) **Solution processed crosslinkable hole injection and hole transport polymers for oleds**

In Flüssigphase verarbeitete, vernetzbare Lochinjektion- und Lochtransport-Polymere für OLEDs.

Polymères réticulables injecteurs et transporteurs de trous traités par solution pour des OLEDs.

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **08.08.2005 US 200453**

(43) Date of publication of application:
14.02.2007 Bulletin 2007/07

(73) Proprietor: **OSRAM OLED GmbH**
93049 Regensburg (DE)

(72) Inventors:
- **So, Franky**
  San Jose, CA 95129 (US)
- **Su, Wencheng**
  Cupertino, CA 95014 (US)

(74) Representative: **Epping - Hermann - Fischer**
Patentanwaltsgesellschaft mbH
Schloßschmidstraße 5
80639 München (DE)

(56) References cited:
WO-A1-2005/024971
JP-A- 5 271 652
US-A- 6 107 452
US-A1- 2004 004 433
US-A1- 2005 048 314
US-A1- 2005 158 523

EP 1 753 047 B1

Description

BACKGROUND

[0001] An OLED device could be fabricated from small molecule or polymeric materials. A typical device structure of a polymer light-emitting diode (PLED) consists of an anode (e.g. indium-tin-oxide (ITO)), a hole injection layer (e.g. poly(3,4-ethylenedioxythiopene) :poly(styrene sulfonic acid) (PEDOT:PSS), or polyaniline), an electroluminescent layer, and a cathode layer (e.g. barium covered with aluminum). Among the two organic layers, the function of the hole injection layer is to provide efficient hole injection into subsequent adjacent layers. In addition, hole injection layer also acts as a buffer layer to smooth the surface of the anode and to provide a better adhesion for the subsequent layer. The function of the electroluminescent layer is to transport both types of carriers and to efficiently produce light of desirable wavelength from electron-hole pair (exciton) recombination. Solution-processed polymer light-emitting diodes (PLEDs) have demonstrated advantages such as ease of fabrication, low fabrication cost, and the possibility of producing large area displays. Hole injection layers used in typical PLEDs is usually a conductive polymer doped with polymeric acid in the form of aqueous particle suspension, e.g., PEDOT/PSS. Although this works for some applications, it still has some drawbacks: (1) The particle nature usually requires a relatively thicker layer to avoid pixel short and strong leakage current. (2) The polymeric acid dopant is usually the major component to achieve the required conductivity. This makes the formed layer nonhomogeneous in bulk and surface composition. (3) The dopant acid group is suspected to be electrochemically unstable during device operation.

[0002] Document US2004/0004433 describes an OLED device with a buffer layer, which is disposed between and in electrical communication with the electrode and the emission layer.

[0003] Document US2005/0048314 describes a light emitting polymer device with improved efficiency and lifetime.

BRIEF DESCRIPTION OF THE DRAWING

[0004]

FIG. 1 shows a cross-sectional view of a non-inventive embodiment of an electroluminescent (EL) device 405.

FIG. 2 shows a cross-sectional view of an embodiment of an electroluminescent (EL) device 505 according to at least one embodiment of the invention.

FIG. 3A illustrates current density versus voltage for a non-inventive bi-layer devices with and without conductivity dopants.

FIG. 3B illustrates luminous efficiency for a non-inventive bi-layer devices with and without conductivity dopants.

FIG. 3C illustrates lifetime data for a non-inventive bi-layer devices with and without conductivity dopants.

FIG. 4A illustrates current density versus voltage for non-inventive tri-layer devices with and without conductivity dopants.

FIG. 4B illustrates luminous efficiency for non inventive tri-layer devices with and without conductivity dopants.

FIG. 4C illustrates lifetime data for non-inventive tri-layer devices with and without conductivity dopants.

[0005] The invention relates to a polymer light-emitting diode as defined in claim 1.

[0006] The invention further relates to a method for fabricating a polymer light-emitting diode.

[0007] In various embodiments of the invention, a solution-processed PLED device (and method of making same) is disclosed which does not utilize a conventional conductive polymer hole injection layer. One or more embodiments utilizes one or more crosslinkable arylamine-type hole injection/transport polymers along with conductivity dopants. This eliminates the use of the acidic hole injection/transport layers such as PEDOT:PSS. Advantageously, both the uncrosslinked arylamine-type polymer and the conductivity dopant material are completely solution soluble. This eliminates the drawbacks associated with particle suspension. All the other layers in the PLED, such as light-emitting polymer layer, can also be solution-processed. Some features of the various embodiments of the invention are listed below.

(1) The use of crosslinkable materials ensures that the hole injection/transport layer will become insoluble to the solvent used to deposit subsequent adjacent layers (e.g., emissive layer) so as to avoid intermixing between adjacent layers. Alternatively, modifying the polarity of the materials can be used to adjust the solubility. The solution-processable hole injection/transport materials can be selected from arylamine-based polymers, aromatic amine-based small molecules, and copolymers or blends of different hole transport materials. In case of small molecules, they have to be blended with a polymer to obtain better film-forming property. The crosslinkable groups could be from either the small molecule, the polymer, or both.

(2) Conductivity dopants are used to increase the conductivity of the arylamine-type hole injection/transport materials. Such conductivity dopants can reduce the voltage drop along the hole injection/transport layer and improve device stability. Both inorganic and organic conductivity dopants can be used. Examples of inorganic dopants include ferric chloride ($FeCl_3$), ferric bromide ($FeBr_3$), antimony pentachloride ($SbCl_5$), arsenic pentachlo-

ride($AsCl_5$), boron trifluoride (BF_3), etc. The examples of organic dopants include 2,3,5,6-tetrafluoro-7,7,8,8-tetracyano-quinodimethane (F4-TCNQ), dicyanodichloroquinone, and trinitrofluorenone, etc. A common solvent for the dopant materials and the arylamine polymers will be used to obtain a homogeneous solution. The molar percentage of such a materials can be varied from 0.001% to 60% in the final films, preferably from 1-10%.

(3) Such a hole injection/transport layer should have proper energy alignment with both the anode (ITO) and the lighting emitting polymer layer. Two separate crosslinkable layers are used according to the invention, where the first layer is responsible for hole injection and the second layer is responsible for hole transport. Both layers contain conductivity dopants.

[0008] In at least one comparative embodiment, disclosed is an electroluminescent (EL) device with a bi-layer organic stack comprising a hole injection/transport layer (HIL) which is composed of 1) a crosslinkable hole injection/transport polymer and 2) one or more conductivity dopants. The HIL can be rendered insoluble by the use of cross-linking so that it does not degrade by the solvent used to fabricate the emissive layer. The term degrade" as used herein means significant physical and/or chemical change has occurred, e.g., dissolving, intermixing, delaminating, etc. In embodiments of the invention, an electroluminescent device is disclosed with a tri-layer organic stack comprising a hole injection layer (HIL) which is composed of a crosslinkable hole injection material and at least one conductivity dopant and a hole transport interlayer which includes a crosslinked hole transport material and conductivity dopants. In various embodiments, in both bi-layer and tri-layer devices, the HIL can be composed of a small molecule material such as an aromatic amine in a polymer binder along with a cross-linking side-group.

[0009] FIG. 1 shows a cross-sectional view of an comparative embodiment of an electroluminescent (EL) device 405 according to at least one embodiment of the invention, The EL device 405 may represent one pixel or sub-pixel of a larger display or part of lighting source. As shown in FIG. 1, the EL device 405 includes a first electrode 411 on a substrate 408. As used within the specification and the claims, the term "on" includes when layers are in physical contact or when layers are separated by one or more intervening layers. The first electrode 411 may be patterned for pixilated applications or remain unpatterned for backlight applications.

[0010] One or more organic materials are deposited to form one or more organic layers of an organic stack 416. The organic stack 416 is on the first electrode 411. The organic stack 416 includes a hole injection layer ("HIL") 417 and emissive layer (EML) 420. The OLED device 405 also includes a second electrode 423 on the organic stack 416. Other layers than that shown in FIG. 1 may also be added including barrier, charge transport/injection, and interface layers between or among any of the existing layers as desired. Some of these layers, in accordance with the invention, are described in greater detail below.

Substrate 408:

[0011] The substrate 408 can be any material that can support the organic and metallic layers on it. The substrate 408 can be transparent or opaque (e.g., the opaque substrate is used in top-emitting devices). By modifying or filtering the wavelength of light which can pass through the substrate 408, the color of light emitted by the device can be changed. The substrate 408 can be comprised of glass, quartz, silicon, plastic, or stainless steel; preferably, the substrate 408 is comprised of thin, flexible glass. The preferred thickness of the substrate 408 depends on the material used and on the application of the device. The substrate 408 can be in the form of a sheet or continuous film. The continuous film can be used, for example, for roll-to-roll manufacturing processes which are particularly suited for plastic, metal, and metallized plastic foils. The substrate can also have transistors or other switching elements built in to control the operation of an active-matrix OLED device. A single substrate 408 is typically used to construct a larger display containing many pixels (EL devices) such as EL device 405 repetitively fabricated and arranged in some specific pattern.

First Electrode 411:

[0012] In one configuration, the first electrode 411 functions as an anode (the anode is a conductive layer which serves as a hole-injecting layer and which comprises a material with work function typically greater than about 4.5 eV). Typical anode materials include metals (such as platinum, gold, palladium, and the like); metal oxides (such as lead oxide, tin oxide, ITO (Indium Tin Oxide), and the like); graphite; doped inorganic semiconductors (such as silicon, germanium, gallium arsenide, and the like); and doped conducting polymers (such as polyaniline, polypyrrole, polythiophene, and the like). The first electrode 411 can be transparent, semi-transparent, or opaque to the wavelength of light generated within the device. The thickness of the first electrode 411 can be from about 10 nm to about 1000 nm, preferably, from about 50 nm to about 200 nm, and more preferably, is about 100 nm. The first electrode layer 411 can typically be fabricated using any of the techniques known in the art for deposition of thin films, including, for example, vacuum evaporation, sputtering, electron beam deposition, or chemical vapor deposition.

HIL 417:

[0013] The HIL 417 has good hole conducting properties and is used to effectively inject holes from the first electrode 411 to the EML 420. It also functions as a hole

transporting layer. In accordance with some embodiments of the invention, the HIL 417 consists of a crosslinkable polymer doped with conductivity dopants. In accordance with other embodiments of the invention, the HIL 417 consists of a small molecule with a polymer binder which is doped with conductivity dopants and includes a cross-linking group.

[0014] An exemplary crosslinkable polymer is an arylamine type polymer with aryl-amine moity in the main chain or side chain, e.g. Poly(N,N'-bis(4-butylphenyl)-N,N'-bis(phenyl)-benzidine), Poly((9,9-dihexylfluorenyl-2,7-diyl)-co-(N,N'-bis(4-butylphenyl-1,4-phenylenediamine)), poly(9,9-dioctylfluorene)-alt-N,N'-phenyl-1,4-phenylenediamine, poly(2,7-(9,9-di-n-octylfluorene)-(1,4-phenylene-((4-secbutylphenyl)imino)-1,4-phenylene), etc. In one or more embodiments, small molecule materials include aromatic amines, e.g. tris(N,N-diphenylamino)triphenylamine, tris(methylphenylphenylamino)triphenylamine,etc. Conductivity dopants are used to increase the conductivity of the arylamine-type hole injection/transport materials. Such conductivity dopants can reduce the voltage drop along the hole injection/transport layer and improve device stability. Both inorganic and organic Conductivity dopants can be used. In one or more embodiments, inorganic conductivity dopants comprise, for example, at least one of the following: ferric chloride ($FeCl_3$), ferric bromide ($FeBr_3$), antimony pentachloride ($SbCl_5$), arsenic pentachloride ($AsCl_5$), boron trifluoride (BF_3), etc. In one or more embodiments, organic conductivity dopants comprise, for example, at least one of the following: 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F4-TCNQ), dicyanodichloroquinone, and trinitrofluorenone, etc.

[0015] A solvent (e.g., chlorobenzene, dichlorobenzene), which can dissolve both the dopant materials and the arylamine polymers, will be used to obtain a homogeneous solution. The molar percentage of such a dopant materials can be varied from 0.001% to 60% in the final films, preferably from 1-10%. The HIL 417 can have a final film thickness from about 5 nm to about 1000 nm, and is conventionally from about 50 nm to about 250 nm. The HIL 417 can be formed using selective deposition techniques or nonselective deposition techniques. Examples of selective deposition techniques include, for example, ink jet printing, flex printing, and screen printing. Examples of nonselective deposition techniques include, for example, spin coating, dip coating, web coating, and spray coating.

[0016] In accordance with at least one embodiment of the invention, however, the preferred method of fabrication includes the following: One or more conductivity dopants are blended, mixed or matrixed with a crosslinkable hole injection/transport polymer material or a small molecule with a polymer binder. The materials are then deposited on the first electrode 411 (preferably by spin coating) and then allowed to dry into a film. The dried film is then cross-linked by thermal, chemical or other irradiative means (ultra-violet curing) and become insoluble to the solvents used in a layer deposited upon it (such as EML 420). The cross-linked film represents the HIL 417. In some embodiments, the crosslinking of the deposited composition can be initiated immediately after deposition such that drying and cross-linking occur contemporaneously. This may include the use of ultraviolet curable inks, crosslinkable side chains, crosslinkable chain end groups, monomers which can be cross-linked into polymers, cross-linking agents, initiators, polymer blends, polymer matrices and so on. The general process(s) of cross-linking organic materials is well-known, and will not be described further. As one possible alternative to cross-linking (not being part of the present invention), the HIL 417 can be rendered insoluble by adjusting its polarity in accordance with the polarity of the solvent (e.g. toluene, xylene etc.) that is to be used in fabricating the EML 420.

EML 420:

[0017] For organic LEDs (OLEDs), the EML 420 contains at least one organic material that emits light. These organic light emitting materials generally fall into two categories: small-molecule light emitting materials and polymer light-emitting materials. In embodiments of the invention, devices utilizing polymeric active electronic materials in EML 420 are especially preferred (in PLEDs). The polymers may be organic or organo-metallic in nature. As used herein, the term organic also includes organo-metallic materials. Light-emission in these materials may be generated as a result of fluorescence or phosphorescence.

[0018] Preferably, these polymers are solvated in an organic solvent, such as toluene or xylene, and spun (spin-coated) onto the device, although other deposition methods are possible too.

[0019] The light emitting organic polymers in the EML 420 can be, for example, electroluminescent (EL) polymers having a conjugated repeating unit, in particular EL polymers in which neighboring repeating units are bonded in a conjugated manner, such as polythiophenes, polyphenylenes, polythiophenevinylenes, or poly-p-phenylenevinylenes or their families, copolymers, derivatives, or mixtures thereof. More specifically, organic polymers can be, for example: polyfluorenes; poly-p-phenylenevinylenes that emit white, red, blue, yellow, or green light and are 2-, or 2, 5-substituted poly-p-phenylenevinylenes; polyspiro polymers. In addition to polymers, smaller organic molecules that emit by fluorescence or by phosphorescence can serve as a light emitting material residing in EML 420. Combinations of PLED materials and smaller organic molecules can also serve as active electronic layer. For example, a PLED may be chemically derivatized with a small organic molecule or simply mixed with a small organic molecule to form EML 420. Examples of electroluminescent small molecule materials include tris(8-hydroxyquinolate) aluminum (Alq_3), anthracene, rubrene, tris(2-phenylpyridine) iridium ($Ir(ppy)_3$), triazine, any metal-chelate compounds and derivatives of any of

these materials. Those materials will be applied by solutions methods.

[0020] In addition to materials that emit light, EML 420 can include a material capable of charge transport. Charge transport materials include polymers or small molecules that can transport charge carriers. For example, organic materials such as polythiophene, derivatized polythiophene, oligomeric polythiophene, derivatized oligomeric polythiophene, pentacene, triphenylamine, and triphenyldiamine. EML 420 may also include semiconductors, such as silicon, gallium arsenide, cadmium selenide, or cadmium sulfide.

[0021] All of the organic layers such as HIL 417 and EML 420 can be ink-jet printed by depositing an organic solution or by spin-coating, or other solution-based deposition techniques. This organic solution may be any "fluid" or deformable mass capable of flowing under pressure and may include solutions, inks, pastes, emulsions, dispersions and so on. The liquid may also contain or be supplemented by further substances which affect the viscosity, contact angle, thickening, affinity, drying, dilution and so on of the deposited drops.

[0022] Further, EML 420 may also be cross-linked or otherwise physically or chemically hardened as desired for stability and maintenance of certain surface properties desirable for deposition of subsequent layers.

Second Electrode (423)

[0023] In one embodiment, second electrode 423 functions as a cathode when an electric potential is applied across the first electrode 411 and the second electrode 423. In this embodiment, when an electric potential is applied across the first electrode 411, which serves as the anode, and second electrode 423, which serves as the cathode, photons are released from EML 420 and pass through first electrode 411 and substrate 408.

[0024] While many materials, which can function as a cathode, are known to those of skill in the art, most preferably a composition that includes aluminum, indium, silver, gold, magnesium, calcium, lithium fluoride, cesium fluoride, sodium fluoride, and barium, or combinations thereof, or alloys thereof, is utilized. Aluminum, aluminum alloys, and combinations of magnesium and silver or their alloys can also be utilized. In some embodiments of the invention, a second electrode 423 is fabricated by thermally evaporating in a two layer or combined fashion barium and aluminum in various amounts.

[0025] Preferably, the total thickness of second electrode 423 is from about 3 to about 1000 nanometers (nm), more preferably from about 50 to about 500 nm, and most preferably from about 100 to about 300 nm. While many methods are known to those of ordinary skill in the art by which the second electrode material may be deposited, vacuum deposition methods, such as physical vapor deposition (PVD) are desirable.

[0026] Often other steps such as washing and neutralization of films, addition of masks and photo-resists may precede cathode deposition. However, these are not specifically enumerated as they do not relate specifically to the novel aspects of the invention. Other steps (not described) like adding metal lines to connect the anode lines to power sources may also be desirable. Other layers (not shown) such as a barrier layer and/or getter layer and/or other encapsulation scheme may also be used to protect the electronic device. Such other processing steps and layers are well-known in the art and are not specifically discussed herein.

[0027] FIG. 2 shows a cross-sectional view of an embodiment of a polymer light-emitting diode 505 according to at least one embodiment of the invention. Device 505 is similar or identical to device 405 in all aspects with like-numbered elements having the same or similar descriptions, except for the following. Organic stack 516 comprises at least three layers EML 420, a hole transporting (HT) interlayer 518 and a hole injection layer (HIL) 517. Unlike HIL 417 which combines hole transport and hole injection functionalities, organic stack 516 divides these functions into separate layers 517 and 518.

HIL 517:

[0028] The HIL 517 has good hole conducting properties and is used to effectively inject holes from the first electrode 411 to the EML 420 via hole transport (HT) interlayer 518. It also functions as a hole transporting layer. In accordance with some embodiments of the invention, the HIL 417 comprises a crosslinkable polymer which is doped with conductivity dopants.

[0029] In accordance with other embodiments of the invention, the HIL 417 comprises a small molecule with a polymer binder which is doped with conductivity dopants and includes a cross-linking group.

[0030] An exemplary crosslinkable polymer is an aryl-amine type polymer with aryl-amine moity in the main chain or side chain, e.g. Poly(N,N'-bis(4-butylphenyl)-N,N'-bis(phenyl)-benzidine), Poly((9,9-dihexylfluorenyl-2,7-diyl)-co-(N,N'-bis(4- butylphenyl-1,4-phenylenediamine)),poly(9,9-dioctylfluorene)-alt-N, N'-phenyl-1,4-phenylenediamine, poly(2,7-(9,9-di-n-octylfluorene)-(1,4-phenylene-((4-secbutylphenyl)imino)-1,4-phenylene), etc.. In one or more embodiments, small molecule materials include aromatic amines, e.g., tris (N,N-diphenylamino)triphenylamine, tris(methylphenylphenylamino)triphenylamine, etc.

[0031] In accordance with at least one embodiment of the invention, HIL 517 includes one or more organic and/or inorganic conductivity dopants. In one or more embodiments, inorganic conductivity dopants comprise at least one of the following: ferric chloride ($FeCl_3$), ferric bromide ($FeBr_3$), antimony pentachloride ($SbCl_5$), arsenic pentachloride($AsCl_5$), boron trifluoride (BF_3), etc. In one or more embodiments, organic conductivity dopants comprise, for example, at least one of the following: 2,3,5,6-tetrafluoro-7,7,8,8-tetracyano-quinodimethane (F4-TCNQ), dicyanodichloroquinone, and trinitroflu-

orenone, etc. The HIL is cross-linked or may, according to an example not forming part of the invention, be physically or chemically rendered insoluble to prevent degradation of the HIL 517 when exposed to the solvent used in fabrication of subsequent adjacent layers such as the HT interlayer 518. Cross-linking can be achieved by exposing the film or deposited solution of HIL 517 to light, ultraviolet radiation, heat, or by chemical process. This may include the use of ultraviolet curable inks, crosslinkable side chains, crosslinkable chain end groups, monomers which can be cross-linked into polymers, cross-linking agents, initiators, polymer blends, polymer matrices and so on. The general process(s) of cross-linking organic materials is well-known, and will not be described further. As one possible alternative to cross-linking, not being part of the present invention, the HIL 517 can be rendered insoluble by adjusting its polarity in accordance with the polarity of the solvent (e.g. toluene, xylene etc.) that is to be used in fabricating the HT interlayer 518. The HIL 517 can be fabricated prior to or in conjunction with the cross-linking process by ink-jet printing, by spin-coating or other proper deposition techniques.

HT interlayer 518:

[0032] The functions of the HT interlayer 518 are among the following: to assist.injection of holes into the EML 420, reduce exciton quenching, provide better hole transport than electron transport, and block electrons from getting into the HIL 517 and degrading it. Some materials may have one or two of the desired properties listed, but the effectiveness of the material as an interlayer is believed to improve with the number of these properties exhibited. The HT interlayer 518 may consist at least partially of or may derive from one or more following compounds, their derivatives, moieties, etc; polyfluorene derivatives, poly(2,7-(9,9-di-n-octylfluorene)-(1,4-phenylene-((4-secbutylphenyl)imino)-1,4-phenylene) and derivatives which include cross-linkable forms, non-emitting forms of poly(p-phenylenevinylene), triarylamine type material (e.g. triphenyldiamine (TPD), α-napthylphenyl-biphenyl (NPB)) mixed with a crosslinkable small molecule or polymer matrix, thiopene, oxetane-functionalized polymers and small molecules etc. The hole transporting materials used in the HT interlayer 518 are preferably polymer hole transporting materials, but can be small molecule hole transporting materials with a polymer binder. For example, polymers containing aromatic amine groups in the main chain or side chains are widely used as hole transporting materials. Preferably, the thickness for the HT interlayer 518 is 10-150 nm. More preferably the thickness for the HT interlayer 518 is 20-60 nm. In embodiments of the invention, the HT interlayer 518 is fabricated using a cross-linkable hole transporting polymer.

[0033] In accordance with at least one embodiment of the invention, HT interlayer 518 includes one ore more organic and/or inorganic conductivity dopants. In one or more embodiments, inorganic conductivity dopants comprise, for example, at least one of the following: ferric chloride ($FeCl_3$), ferric bromide ($FeBr_3$), antimony pentachloride ($SbCl_5$), arsenic pentachloride($AsCl_5$), boron trifluoride (BF_3), etc. In one or more embodiments, organic conductivity dopants comprise, for example, at least one of the following: 2,3,5,6-tetrafluoro-7,7,8,8-tetracyano-quinodimethane (F4-TCNQ), dicyanodichloroquinone, and trinitrofluorenone, etc. The HT interlayer 518 is cross-linked or may, according to an example not being part of the present invention, be physically or chemically rendered insoluble to prevent degradation of the HT interlayer 518 when exposed to the solvent used in fabrication of subsequent adjacent layers such as the EML 420. Cross-linking can be achieved by exposing the film or deposited solution of HT interlayer 518 to light, ultraviolet radiation, heat, or by chemical process. This may include the use of ultraviolet curable inks, crosslinkable side chains, crosslinkable chain end groups, monomers which can be cross-linked into polymers, cross-linking agents, initiators, polymer blends, polymer matrices and so on. The general process(s) of cross-linking organic materials is well-known, and will not be described further. As one possible aternative to cross-linking, not being part of the present invention, the HT interlayer 518 can be rendered insoluble by adjusting its polarity in accordance with the polarity of the solvent (e.g. toluene, xylene etc.) that is to be used in fabricating the EML 420. The HT interlayer 518 can be fabricated prior to or in conjunction with the cross-linking process by ink-jet printing, by spin-coating or other proper deposition techniques.

[0034] In accordance with at least one embodiment of the invention, the preferred method of fabrication of device 505 includes the following: One or more conductivity dopants are blended, mixed or matrixed with a crosslinkable hole injection polymer material or a small molecule with a polymer binder. The materials are then deposited on the first electrode 411 (preferably by spin coating) and then allowed to dry into a film. The dried film is then cross-linked by thermal, chemical or other irradiative means (ultra-violet curing) and become insoluble to the solvents used in a layer deposited upon it (such as HT interlayer 518). The cross-linked film represents the HIL 517. In some embodiments, the crosslinking of the deposited composition can be initiated immediately after deposition such that drying and cross-linking occur contemporaneously. For HT interlayer 518, one ore more conductivity dopants are blended, mixed or matrixed with a crosslinkable hole transporting polymer material or a small molecule with a polymer binder. These materials are then deposited on the HIL 517 (preferably by spin coating) and then allowed to dry into a film. The dried film is then cross-linked by thermal, chemical or other irradiative means (ultra-violet curing) and become insoluble to the solvents used in a layer deposited upon it (such as EML 420). The cross-linked film represents the HT interlayer 518. In some embodiments, the crosslinking of the deposited

materials can be initiated immediately after deposition such that drying and cross-linking occur contemporaneously.

Energy Alignment

[0035] For Bi-layer organic stack devices such as device 405 of FIG. 1 according to a comparative example, the hole injection/transport material used in HIL 417 is selected to have a better or close energy match with the first electrode 411 (the anode). This alignment allows holes to be transported more easily from the first electrode 411 to the EML 420. For a tri-layer organic stack device such as device 505 of FIG. 2, the hole injection material used in HIL 517 is selected to have a better or close energy match with the first electrode 411 (the anode). This alignment allows holes to be injected more easily from the first electrode 411 to the HT interlayer 518. The hole transporting material used in HT interlayer 518 is selected to have to a better or close energy match with the EML 420 so that holes that are injected can be more easily transported to (accepted by) EML 420. FIG. 3A illustrates current density versus voltage for bi-layer devices with and without conductivity dopants according to a comparative example. A first device, labeled "Bilayer Control" has the following essential structure: Anode: ITO (Indium Tin Oxide)/HIL: 45 nm of an aryl-amine crosslinkable polyfluorene/ EML: 75 nm orange polyfluorene-type LEP and Cathode: 6 nm barium and 200 nm aluminum. A second device labeled "Doped Bilayer" has the following essential structure: Anode: ITO (Indium Tin Oxide)/HIL; 45 nm of an aryl-amine crosslinkable polyfluorene doped with 4% molar F_4-TCNQ/ EML: 75 nm orange polyfluorene-type LEP and cathode: 6 nm barium and 200 nm aluminum. In each device the HIL was crosslinked to render it insoluble to the solvent used in fabricating the EML. In the Doped Bilayer device, current density is increased in all cases and dramatically so at over 4 volts. This indicates improved hole injection and transport resulting in greater current flow.

[0036] FIG. 3B illustrates luminous efficiency for bi-layer devices with and without conductivity dopants according to a comparative example. The same two devices, Doped Bilayer and Bilayer Control, described above with respect to FIG. 3A were tested for luminous or photopic efficiency. The Bilayer Control device had a maximum of 200 mA/cm^2 current (at 8 volts, see FIG. 3A) while the Doped Bilayer had current flow up to around 1000 mA/cm^2 at the same voltage. The Doped Bilayer device shows a luminous efficiency roughly twice or 100% greater that of the Bilayer Control device. Luminous efficiency was measured in units of Cd/A.

[0037] FIG. 3C illustrates lifetime data for bi-layer devices with and without conductivity dopants according to a comparative example. The same two devices, Doped Bilayer and Bilayer Control, described above with respect to FIG. 3A were tested for lifetime. The lifetime testing was performed at room temperature under a multiplexed driving scheme with a duty cycle of 1/64 (mux 64). As shown, with the Doped Bilayer device there is little if any drop in normalized luminance over the first 200 hours. By contrast, with the Bilayer Control device, there is a large initial luminance drop within the first 20 or so hours of operation. This shows better lifetime and markedly better operational stability over time in the Doped Bilayer device.

[0038] FIG. 4A illustrates current density versus voltage for tri-layer devices with and without conductivity dopants according to an example not being part of the present invention. A first device, labeled "Trilayer Control has the following essential structure: Anode: ITO (Indium Tin Oxide)/HIL; 45 nm of an aryl-amine crosslinkable polyfluorene/HT interlayer: 30 nm hole transporting polymer/ EML: 75 nm orange LEP and Cathode: 6 nm barium and 200 nm aluminum. A second device labeled "Doped Trilayer" has the following essential structure: Anode: ITO (Indium Tin Oxide)/HIL: 45 nm of an aryl-amine crosslinkable polyfluorene doped with 4% molar F_4-TCNQ/HT interlayer: 30 nm hole transporting polymer/EML: 75 nm orange polyfluorene-type LEP and Cathode: 6 nm barium and 200 nm aluminum. In each device both the HIL and the HT interlayer was crosslinked to render it insoluble. In the Doped Trilayer device, current density is increased in all cases and dramatically so at over 4 volts. This indicates improved hole injection and transport resulting in greater current flow.

[0039] FIG. 4B illustrates luminous efficiency for tri-layer devices with and without conductivity dopants according to an example not being part of the present invention. The same two devices, Doped Trilayer and Trilayer Control, described above with respect to FIG. 4A were tested for luminous or photopic efficiency. The Trilayer Control device had a maximum of about 700 mA/cm^2 current (at 8 volts, see FIG. 4A) while the Doped Trilayer had current flow up to around 1000 mA/cm^2 at the same voltage. The Doped Tri-layer device shows a luminous efficiency much greater that of the Trilayer Control device at all current densities. Luminous efficiency was measured in units of Cd/A. FIG. 4C illustrates lifetime data for tri-layer devices with and without conductivity dopants according to an example not being part of the present invention. The same two devices, Doped Trilayer and Trilayer Control, described above with respect to FIG. 4A were tested for lifetime. The lifetime testing was performed at room temperature under a multiplexed driving scheme with a duty cycle of 1/64 (mux 64). As shown, with the Doped Trilayer device there is little if any drop in normalized luminance over the first 200 hours. This shows better lifetime and markedly better operational stability over time in the Doped Trilayer device when compared to the Trilayer Control device.

[0040] As any person of ordinary skill in the art of electronic device fabrication will recognize from the description, figures, and examples that modifications and changes can be made to the embodiments of the invention without departing from the scope of the invention defined

by the following claims.

Claims

1. A polymer light-emitting diode (505) having a plurality of layers, comprising:

   an anode layer (411);
   a hole injection layer (517) disposed over said anode layer (411), said hole injection layer (517) comprises a crosslinked hole injection material doped with at least one conductivity dopant selected from a group comprising ferric chloride ($FeCl_3$), ferric bromide ($FeBr_3$), antimony pentachloride ($SbCl_5$), arsenic pentachloride($AsCl_5$), boron trifluoride (BF_3), 2,3,5,6-tetrafluoro-7,7,8,8-tetracyano-quinodimethane (F_4-TCNQ), dicyanodichloroquinone, and trinitrofluorenone; said hole injection layer being in physical contact with the anode, and
   a hole transporting interlayer (518) disposed over said hole injection layer (517), said hole transporting interlayer (518) comprises a crosslinked hole transporting material doped with at least one conductivity dopant,
   wherein each of the hole injection layer (517) and the hole transporting interlayer (518) is free of PEDOT:PSS.

2. The polymer light-emitting diode according to the preceding claim wherein said crosslinked hole injection material includes an aryl-amine type polymer.

3. The polymer light-emitting diode according to claim 1 wherein said crosslinked hole injection material comprises a polyfluorene based polymer.

4. The polymer light-emitting diode according to claim 1 wherein said crosslinked hole injection material is a small molecule material with a polymer binder.

5. The polymer light-emitting diode according to claim 4 wherein the small molecule material comprises an arylamine-based small molecule.

6. The polymer light-emitting diode according to any of the preceding claims wherein said hole injection layer (517) is fabricated such that it has a close energy alignment with said anode (411).

7. The polymer light-emitting diode according to any of the preceding claims further comprising:

   an emissive layer (420) disposed over said hole transporting interlayer (518), said emissive layer (420) capable of emitting light.

8. The polymer light-emitting diode according to claim 7 further comprising:

   a cathode layer (423) disposed above said emissive layer (420).

9. The polymer light-emitting diode according to any of the preceding claims wherein the at least one conductivity dopant of the hole transporting interlayer (518) includes at least one of: ferric chloride ($FeCl_3$), ferric bromide ($FeBr_3$), antimony pentachloride ($SbCl_5$), arsenic pentachloride($AsCl_5$), boron trifluoride (BF_3), 2,3,5,6-tetrafluoro-7,7,8,8-tetracyano-quinodimethane (F_4-TCNQ), dicyanodichloroquinone, and trinitrofluorenone.

10. The polymer light-emitting diode according to any of the preceding claims wherein said hole transporting interlayer (518) is fabricated such that it has a close energy alignment with said emissive layer (420).

11. A method for fabricating a polymer light-emitting diode (505), comprising:

   fabricating an anode layer (411);
   blending a hole injection material with at least one conductivity dopant selected from a group comprising ferric chloride ($FeCl_3$), ferric bromide ($FeBr_3$), antimony pentachloride ($SbCl_5$), arsenic pentachloride($AsCl_5$), boron trifluoride (BF_3), 2,3,5,6-tetrafluoro-7,7,8,8-tetracyano-quinodimethane (F_4-TCNQ), dicyanodichloroquinone, and trinitrofluorenone ;
   fabricating a hole injection layer (517) from said blend over said anode layer, said hole injection layer being in physical contact with the anode (411);
   fabricating a hole transporting interlayer (518) from a hole transporting material over said hole injection layer (517), wherein the hole transporting interlayer (518) comprises at least one conductivity dopant;
   fabricating an emissive layer (420) over said hole transporting interlayer (518);
   prior to fabricating said hole transporting interlayer (518), cross-linking said hole injection layer (517), so that the hole injection layer (517) is insoluble to a solvent used in fabricating the hole transporting interlayer (518); and
   prior to fabricating said emissive layer (420), cross-linking the hole transporting interlayer (518), so that the hole transporting interlayer (518) is insoluble to a solvent used in fabricating the emissive layer (420),
   wherein each of the hole injection layer (517) and the hole transporting interlayer (518) is free of PEDOT:PSS.

12. The method according to claim 11 wherein the at least one conductivity dopant of the hole transporting interlayer (518) includes at least one of: ferric chloride ($FeCl_3$), ferric bromide ($FeBr_3$), antimony pentachloride ($SbCl_5$), arsenic pentachloride($AsCl_5$), boron trifluoride (BF_3), 2,3,5,6-tetrafluoro-7,7,8,8-tetracyano-quinodimethane (F_4-TCNQ), dicyanodichloroquinone, and trinitrofluorenone.

Patentansprüche

1. Polymer-Leuchtdiode (505) mit einer Mehrzahl von Schichten, umfassend:

eine Anodenschicht (411);
eine Lochinjektionsschicht (517), die über der Anodenschicht (411) angeordnet ist, wobei diese Lochinjektionsschicht (517) ein vernetztes Lochinjektionsmaterial umfasst, das mit mindestens einem Leitfähigkeits-Dotierstoff dotiert ist, der aus einer Gruppe ausgewählt ist, die Eisenchlorid ($FeCl_3$), Eisenbromid ($FeBr_3$), Antimonpentachlorid ($SbCl_5$), Arsenpentachlorid ($AsCl_5$), Bortrifluorid (BF_3), 2,3,5,6 -Tetrafluor-7,7,8,8-tetracyanochinodimethan (F_4-TCNQ), Dicyanodichlorchinon und Trinitrofluorenon umfasst;
wobei sich diese Lochinjektionsschicht in physischem Kontakt mit der Anode befindet, und
eine lochtransportierende Zwischenschicht (518), die über der Lochinjektionsschicht (517) angeordnet ist,
wobei diese lochtransportierende Zwischenschicht (518) ein vernetztes lochtransportierendes Material umfasst, das mit mindestens einem Leitfähigkeits-Dotierstoff dotiert ist,
wobei jede von der Lochinjektionsschicht (517) und der lochtransportierenden Zwischenschicht (518) frei von PEDOT:PSS ist.

2. Polymer-Leuchtdiode nach dem vorhergehenden Anspruch, wobei das vernetzte Lochinjektionsmaterial ein Polymer vom Arylamintyp umfasst.

3. Polymer-Leuchtdiode nach Anspruch 1, wobei das vernetzte Lochinjektionsmaterial ein auf Polyfluoren basierendes Polymer umfasst.

4. Polymer-Leuchtdiode nach Anspruch 1, wobei das vernetzte Lochinjektionsmaterial ein niedermolekulares Material mit einem Polymerbinder ist.

5. Polymer-Leuchtdiode nach Anspruch 4, wobei das niedermolekulare Material ein kleines Molekül auf der Basis von Arylamin umfasst.

6. Polymer-Leuchtdiode nach einem der vorhergehenden Ansprüche, wobei die Lochinjektionsschicht (517) derart hergestellt ist, dass sie eine nahe Energieangleichung mit der Anode (411) aufweist.

7. Polymer-Leuchtdiode nach einem der vorhergehenden Ansprüche, ferner umfassend:

eine Emissionsschicht (420), die über der lochtransportierenden Zwischenschicht (518) angeordnet ist, wobei diese Emissionsschicht (420) dazu eingerichtet ist, Licht zu emittieren.

8. Polymer-Leuchtdiode nach Anspruch 7, ferner umfassend:

eine Kathodenschicht (423), die über der Emissionsschicht (420) angeordnet ist.

9. Polymer-Leuchtdiode nach einem der vorhergehenden Ansprüche, wobei der mindestens eine Leitfähigkeits-Dotierstoff der lochtransportierenden Zwischenschicht (518) mindestens eines von Folgendem umfasst:

Eisenchlorid ($FeCl_3$), Eisenbromid ($FeBr_3$), Antimonpentachlorid ($SbCl_5$), Arsenpentachlorid ($AsCl_5$),
Bortrifluorid (BF_3), 2,3,5,6-Tetrafluor-7,7,8,8-tetracyanochinodimethan (F_4-TCNQ), Dicyanodichlorchinon und Trinitrofluorenon.

10. Polymer-Leuchtdiode nach einem der vorhergehenden Ansprüche, wobei die lochtransportierende Zwischenschicht (518) derart hergestellt ist, dass sie eine nahe Energieangleichung mit der Emissionsschicht (420) aufweist.

11. Verfahren zur Herstellung einer Polymer-Leuchtdiode (505), umfassend:

Herstellen einer Anodenschicht (411);
Vermischen eines Lochinjektionsmaterials mit mindestens einem Leitfähigkeits-Dotierstoff, der aus einer Gruppe ausgewählt ist, die Eisenchlorid ($FeCl_3$), Eisenbromid ($FeBr_3$), Antimonpentachlorid ($SbCl_5$), Arsenpentachlorid($AsCl_5$), Bortrifluorid (BF_3), 2,3,5,6-Tetrafluor-7,7,8,8-tetracyanochinodimethan (F_4-TCNQ), Dicyanodichlorchinon und Trinitrofluorenon umfasst;
Herstellen einer Lochinjektionsschicht (517) aus dieser Mischung über der Anodenschicht, wobei diese Lochinjektionsschicht in physischem Kontakt mit der Anode (411) ist;
Herstellen einer lochtransportierenden Zwischenschicht (518) aus einem lochtransportierenden Material über der Lochinjektionsschicht (517), wobei die lochtransportierende Zwi-

schenschicht (518) mindestens einen Leitfähigkeits-Dotierstoff umfasst;
Herstellen einer Emissionsschicht (420) über der lochtransportierenden Zwischenschicht (518);
vor dem Herstellen der lochtransportierenden Zwischenschicht (518), Vernetzen der Lochinjektionsschicht (517), so dass die Lochinjektionsschicht (517) durch ein zur Herstellung der lochtransportierenden Zwischenschicht (518) verwendetes Lösungsmittel nicht gelöst werden kann; und
vor dem Herstellen der Emissionsschicht (420), Vernetzen der lochtransportierenden Zwischenschicht (518), so dass die lochtransportierende Zwischenschicht (518) durch ein zur Herstellung der Emissionsschicht (420) verwendetes Lösungsmittel nicht gelöst werden kann,
wobei jede von der Lochinjektionsschicht (517) und der lochtransportierenden Zwischenschicht (518) frei von PEDOT:PSS ist.

12. Verfahren nach Anspruch 11, wobei der mindestens eine Leitfähigkeits-Dotierstoff der lochtransportierenden Zwischenschicht (518) mindestens eines von Folgendem umfasst: Eisenchlorid ($FeCl_3$), Eisenbromid ($FeBr_3$), Antimonpentachlorid ($SbCl_5$), Arsenpentachlorid ($AsCl_5$), Bortrifluorid (BF_3), 2,3,5,6-Tetrafluor-7,7,8,8-tetracyanochinodimethan (F_4-TCNQ), Dicyanodichlorchinon und Trinitrofluorenon.

Revendications

1. Diode électroluminescente polymère (505) ayant une pluralité de couches, comprenant :

une couche d'anode (411) ;
une couche d'injection de trou (517) disposée par-dessus ladite couche d'anode (411), ladite couche d'injection de trou (517) comprend un matériau d'injection de trou réticulé dopé avec au moins un dopant de conductivité choisi dans un groupe comprenant du chlorure ferrique ($FeCl_3$), du bromure ferrique ($FeBr_3$), du pentachlorure d'antimoine ($SbCl_5$), du pentachlorure d'arsenic ($AsCl_5$), du trifluorure de bore (BF_3), du 2,3,5,6-tétrafluoro-7,7,8,8.-tétracyano-quinodiméthane (F_4-TCNQ), de la dicyanodichloroquinone et de la trinitrofluorénone ; ladite couche d'injection de trou étant en contact physique avec l'anode, et
une couche intermédiaire de transport de trou (518) disposée par-dessus ladite couche d'injection de trou (517), ladite couche intermédiaire de transport de trou (518) comprend un matériau de transport de trou réticulé dopé avec au moins un dopant de conductivité, dans laquelle chacune parmi la couche d'injection de trou (517) et la couche intermédiaire de transport de trou (518) est exempte de PEDOT:PSS.

2. Diode électroluminescente polymère selon la revendication précédente, dans laquelle ledit matériau d'injection de trou réticulé comprend un polymère de type arylamine.

3. Diode électroluminescente polymère selon la revendication 1, dans laquelle ledit matériau d'injection de trou réticulé comprend un polymère à base de polyfluorène.

4. Diode électroluminescente polymère selon la revendication 1, dans laquelle ledit matériau d'injection de trou réticulé est un matériau à petite molécule avec un liant polymère.

5. Diode électroluminescente polymère selon la revendication 4, dans laquelle le matériau à petite molécule comprend une petite molécule à base d'arylamine.

6. Diode électroluminescente polymère selon l'une quelconque des revendications précédentes, dans laquelle ladite couche d'injection de trou (517) est fabriquée de telle sorte qu'elle présente un alignement d'énergie rapproché avec ladite anode (411).

7. Diode électroluminescente polymère selon l'une quelconque des revendications précédentes, comprenant en outre :

une couche émissive (420) disposée par-dessus ladite couche intermédiaire de transport de trou (518), ladite couche émissive (420) étant capable d'émettre de la lumière.

8. Diode électroluminescente polymère selon la revendication 7, comprenant en outre :

une couche de cathode (423) disposée au-dessus de ladite couche émissive (420).

9. Diode électroluminescente polymère selon l'une quelconque des revendications précédentes, dans laquelle ledit au moins un dopant de conductivité de la couche intermédiaire de transport de trou (518) comprend au moins l'un parmi : du chlorure ferrique ($FeCl_3$), du bromure ferrique ($FeBr_3$), du pentachlorure d'antimoine ($SbCl_5$), du pentachlorure d'arsenic ($AsCl_5$), du trifluorure de bore (BF_3), du 2,3,5,6-tétrafluoro-7,7,8,8-tétracyano-quinodiméthane (F_4-TCNQ), de la dicyanodichloroquinone et de la trinitrofluorénone.

10. Diode électroluminescente polymère selon l'une quelconque des revendications précédentes, dans laquelle ladite couche intermédiaire de transport de trou (518) est fabriquée de telle sorte qu'elle présente un alignement d'énergie rapproché avec ladite couche émissive (420).

11. Procédé de fabrication d'une diode électroluminescente polymère (505), comprenant :

la fabrication d'une couche d'anode (411) ;
le mélange d'un matériau d'injection de trou avec au moins un dopant de conductivité choisi dans un groupe comprenant le chlorure ferrique ($FeCl_3$), le bromure ferrique ($FeBr_3$), le pentachlorure d'antimoine ($SbCl_5$), le pentachlorure d'arsenic ($AsCl_5$), le trifluorure de bore (BF_3), le 2,3,5,6-tétrafluoro-7,7,8,8-tétracyano-quinodiméthane (F_4-TCNQ), la dicyanodichloroquinone et la trinitrofluorénone ;
la fabrication d'une couche d'injection de trou (517) à partir dudit mélange par-dessus ladite couche d'anode, ladite couche d'injection de trou étant en contact physique avec l'anode (411) ;
la fabrication d'une couche intermédiaire de transport de trou (518) à partir d'un matériau de transport de trou par-dessus ladite couche d'injection de trou (517), dans lequel la couche intermédiaire de transport de trou (518) comprend au moins un dopant de conductivité ;
la fabrication d'une couche émissive (420) par-dessus ladite couche intermédiaire de transport de trou (518) ;
avant la fabrication de ladite couche intermédiaire de transport de trou (518), la réticulation de ladite couche d'injection de trou (517), de sorte que la couche d'injection de trou (517) est insoluble vis-à-vis d'un solvant utilisé dans la fabrication de la couche intermédiaire de transport de trou (518) ; et avant la fabrication de ladite couche émissive (420), la réticulation de la couche intermédiaire de transport de trou (518), de sorte que la couche intermédiaire de transport de trou (518) est insoluble vis-à-vis d'un solvant utilisé dans la fabrication de la couche émissive (420),
dans lequel chacune parmi la couche d'injection de trou (517) et la couche intermédiaire de transport de trou (518) est exempte de PEDOT:PSS.

12. Procédé selon la revendication 11, dans lequel ledit au moins un dopant de conductivité de la couche intermédiaire de transport de trou (518) comprend au moins l'un parmi : du chlorure ferrique ($FeCl_3$), du bromure ferrique ($FeBr_3$), du pentachlorure d'antimoine ($SbCl_5$), du pentachlorure d'arsenic ($AsCl_5$), du trifluorure de bore (BF_3), du 2, 3, 5, 6-tétrafluoro-7,7,8,8-tétracyano-quinodiméthane (F_4- TCNQ), de la dicyanodichloroquinone et de la trinitrofluorénone.

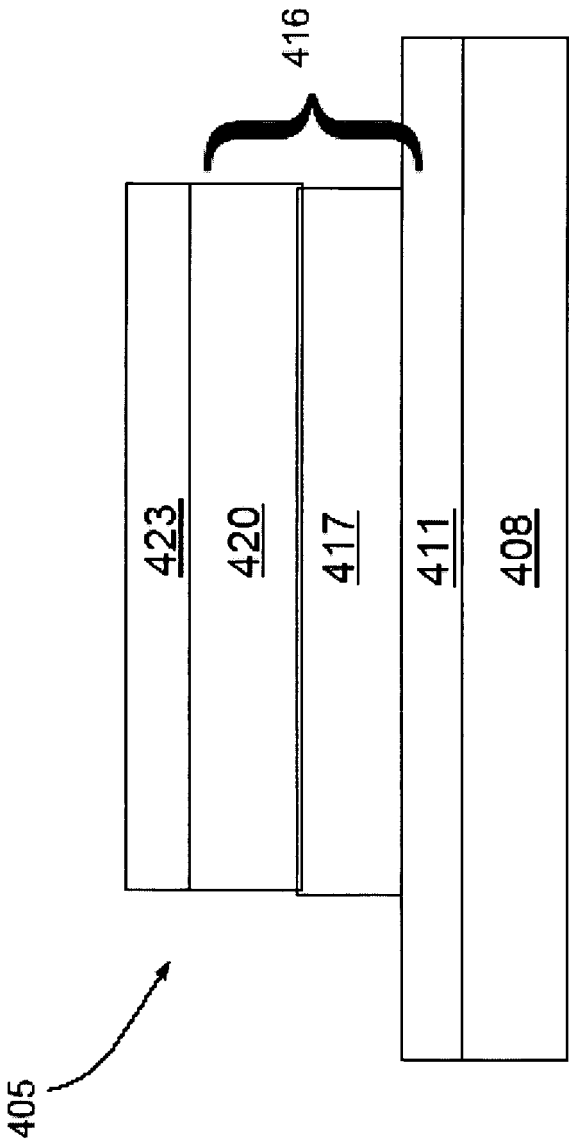

FIG. 1

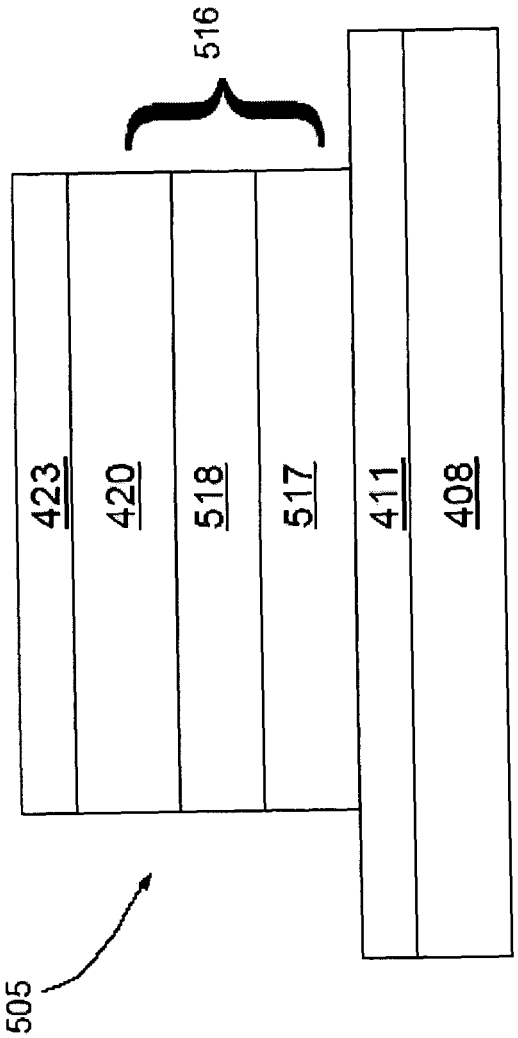

FIG. 2

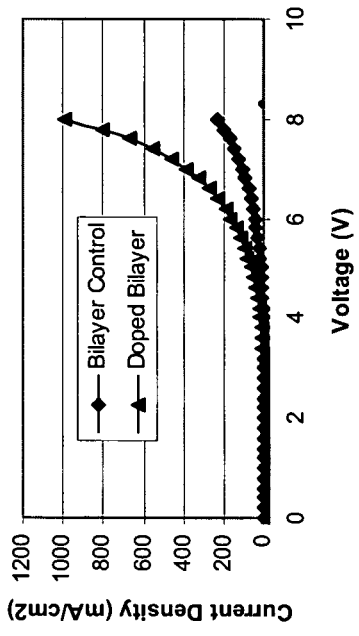

FIG. 3A

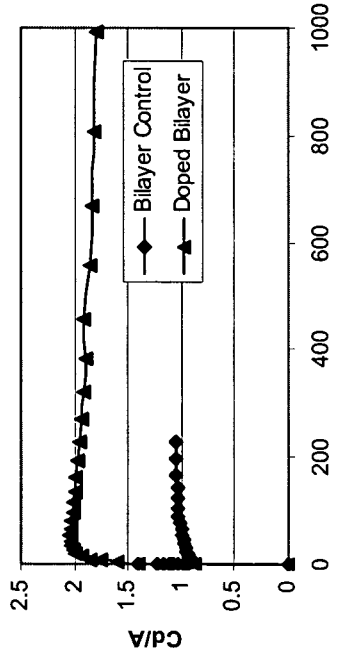

FIG. 3B

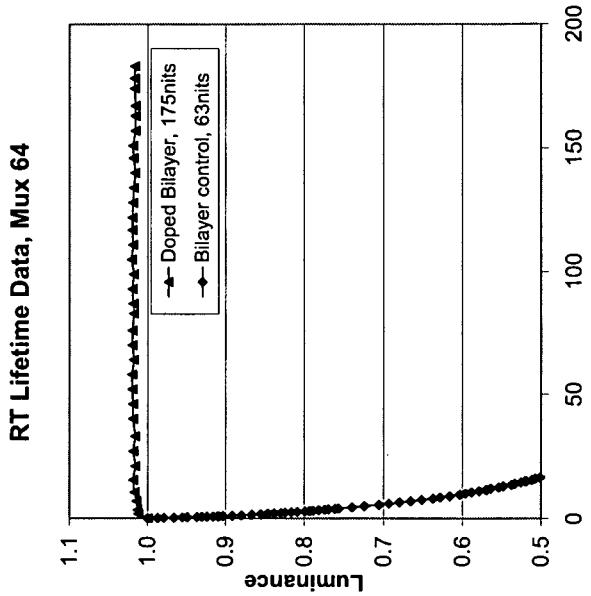

FIG. 3C

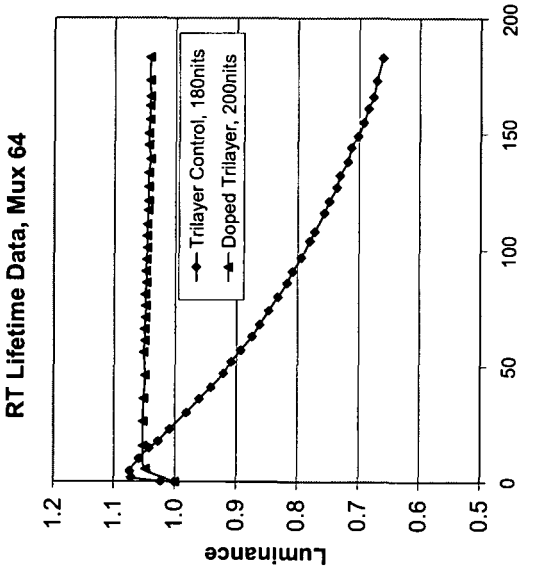

FIG. 4C

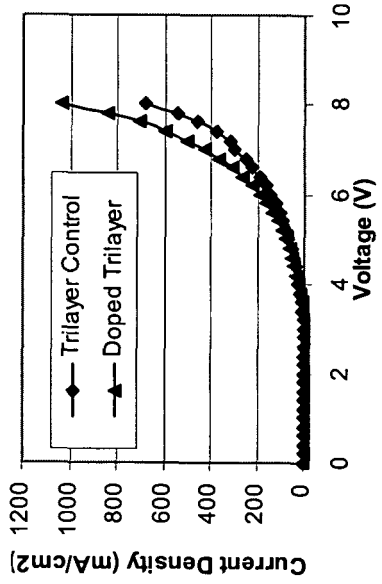

FIG. 4A

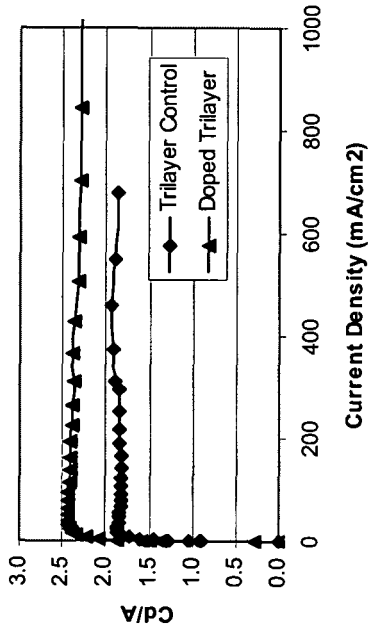

FIG. 4 B

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 20040004433 A **[0002]**
- US 20050048314 A **[0003]**

专利名称(译)	溶液加工的可交联空穴注入和用于oleds的空穴传输聚合物		
公开(公告)号	EP1753047B1	公开(公告)日	2017-04-12
申请号	EP2006015829	申请日	2006-07-28
[标]申请(专利权)人(译)	奥斯兰姆奥普托半导体有限责任公司		
申请(专利权)人(译)	欧司朗光电半导体公司		
当前申请(专利权)人(译)	欧司朗OLED GMBH		
[标]发明人	SO FRANKY SU WENCHENG		
发明人	SO, FRANKY SU, WENCHENG		
IPC分类号	H01L51/50 H01L51/54 H01L51/56		
CPC分类号	H01L51/0034 H01L51/002 H01L51/0036 H01L51/0039 H01L51/0043 H01L51/0059 H01L51/5052 H01L51/5088		
优先权	11/200453 2005-08-08 US		
其他公开文献	EP1753047A3 EP1753047A2		
外部链接	Espacenet		

摘要(译)

完全溶液处理的聚合物电致发光器件（505）具有空穴注入层（517），其使用掺杂有导电性掺杂剂的可交联空穴注入/传输材料制造。

(19) European Patent Office

(11) EP 1 753 047 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent: 12.04.2017 Bulletin 2017/15

(51) Int Cl: H01L 51/50 (2006.01) H01L 51/54 (2006.01) H01L 51/56 (2006.01)

(21) Application number: 06015829.2

(22) Date of filing: 28.07.2006

(54) Solution processed crosslinkable hole injection and hole transport polymers for oleds

In Flüssigphase verarbeitete, vernetzbare Lochinjektion- und Lochtransport-Polymere für OLEDs

Polymères réticulables injecteurs et transporteurs de trous traités par solution pour des OLEDs

(84) Designated Contracting States: AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: 08.08.2005 US 200453

(43) Date of publication of application: 14.02.2007 Bulletin 2007/07

(73) Proprietor: OSRAM OLED GmbH 93049 Regensburg (DE)

(72) Inventors:
- So, Franky
San Jose, CA 95129 (US)
- Su, Wencheng
Cupertino, CA 95014 (US)

(74) Representative: Epping - Hermann - Fischer Patentanwaltsgesellschaft mbH Schloßschmidstraße 5 80639 München (DE)

(56) References cited:
WO-A1-2005/024971 JP-A- 5 271 652
US-A- 6 107 452 US-A1- 2004 004 433
US-A1- 2005 048 314 US-A1- 2005 158 523

EP 1 753 047 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Printed by Jouve 75001 PARIS (FR)