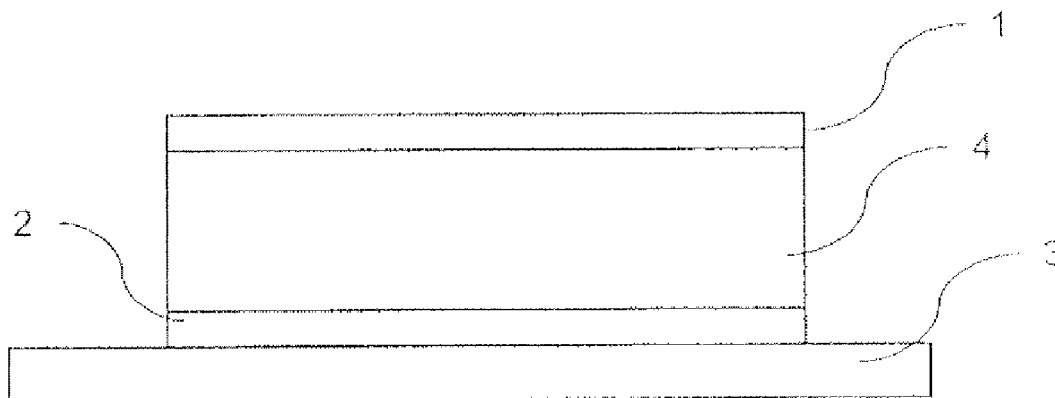




US 20120025171A1

(19) **United States**(12) **Patent Application Publication**
Canzler et al.(10) **Pub. No.: US 2012/0025171 A1**(43) **Pub. Date: Feb. 2, 2012**(54) **ELECTRONIC COMPONENT WITH AT
LEAST ONE ORGANIC LAYER
ARRANGEMENT**(75) Inventors: **Tobias Canzler**, Dresden (DE);
Olaf Zeika, New York, NY (US);
Philipp Wellmann, Darmstadt (DE)(73) Assignee: **NOVALED AG**, Dresden (DE)(21) Appl. No.: **12/519,912**(22) PCT Filed: **Dec. 21, 2007**(86) PCT No.: **PCT/EP07/11353**§ 371 (c)(1),
(2), (4) Date: **Dec. 7, 2009**(30) **Foreign Application Priority Data**Dec. 22, 2006 (EP) 06026743.2
Dec. 21, 2007 (WO) PCTEP2007011353**Publication Classification**(51) **Int. Cl.**
H01L 51/52 (2006.01)
H01L 51/54 (2006.01)
(52) **U.S. Cl.** **257/40**; 257/E51.018; 257/E51.024
(57) **ABSTRACT**

An electronic component, having an anode, a cathode and at least one organic layer arrangement, arranged between the anode and cathode and is in electrical contact with the anode and cathode and has at least one of the following: a zone which generates electrical charges upon application of an electric potential to the anode and cathode and has an np-junction, which is formed with a layer of a p-type organic semiconductor material and an n-doped layer of an n-type organic semiconductor material, which is in contact with a conductive layer of the anode, and a zone which generates further electrical charges upon application of the electric potential to the anode and cathode and has a pn-junction, which is formed with a layer of an n-type organic semiconductor material and a p-doped layer of a p-type organic semiconductor material, which is in contact with a conductive layer of the cathode.



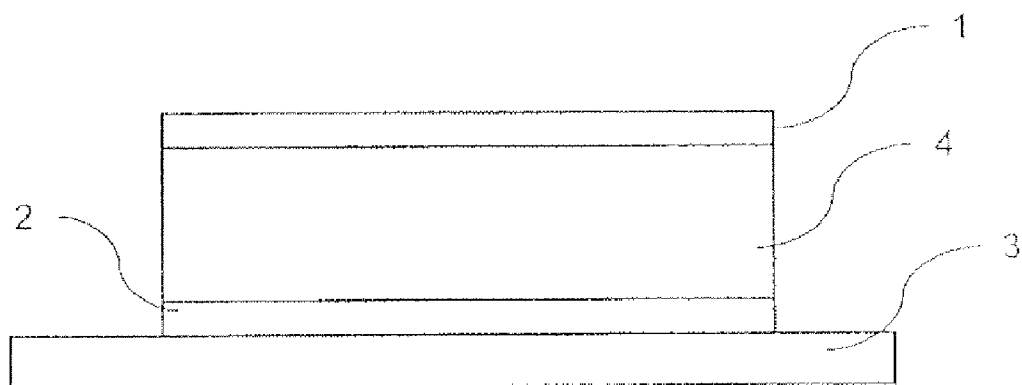


Fig. 1

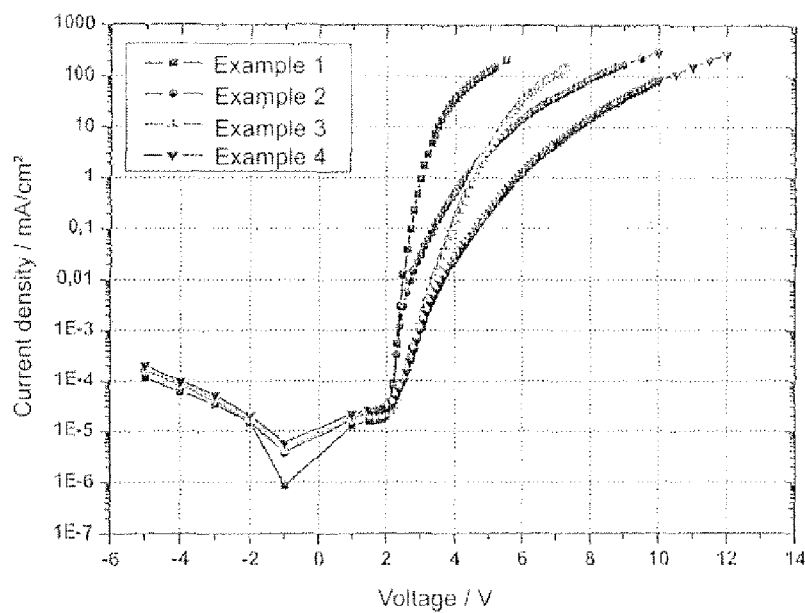


Fig. 2

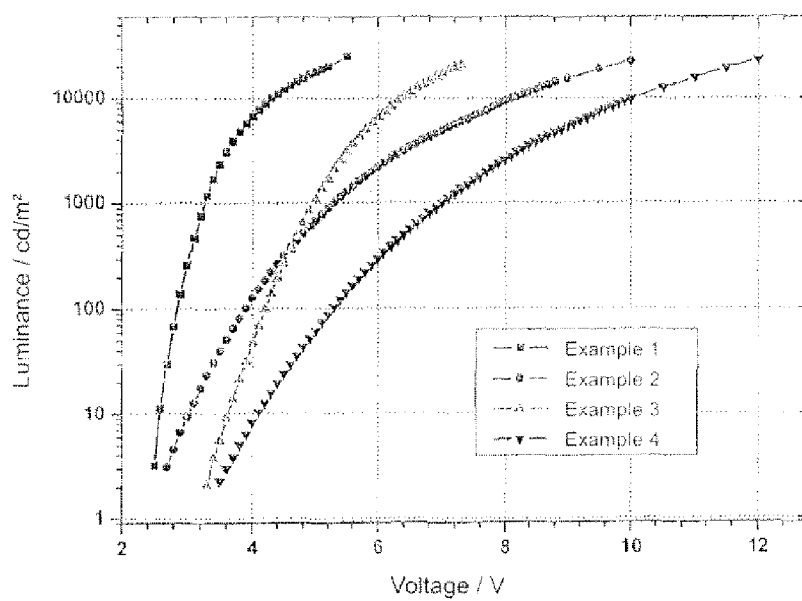


Fig. 3

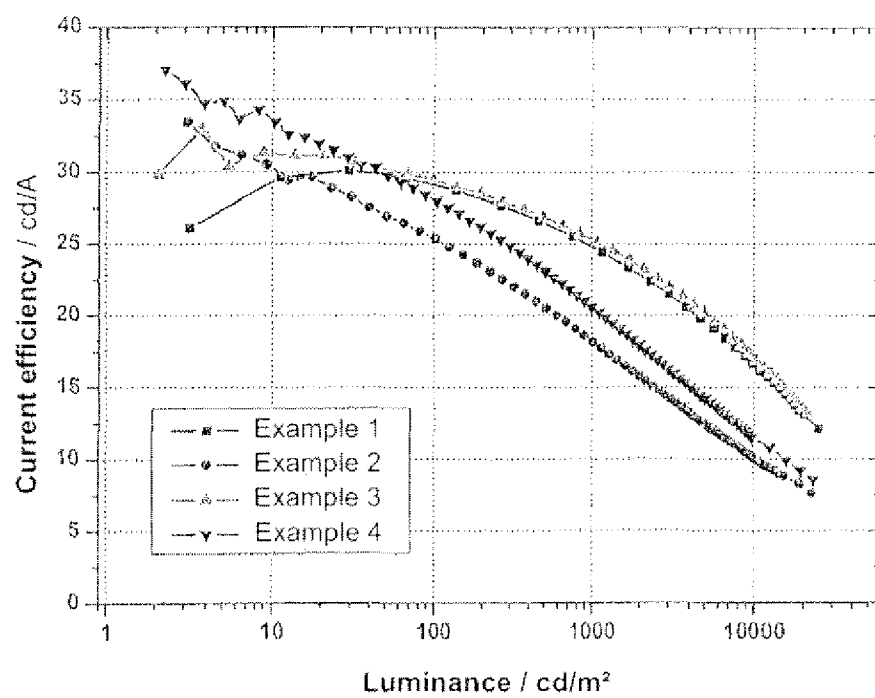


Fig. 4

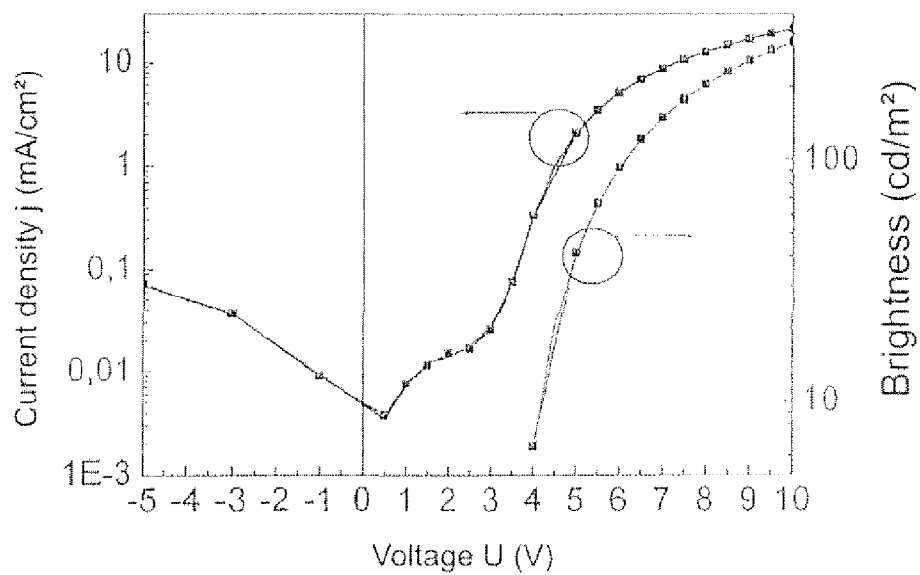


Fig. 5

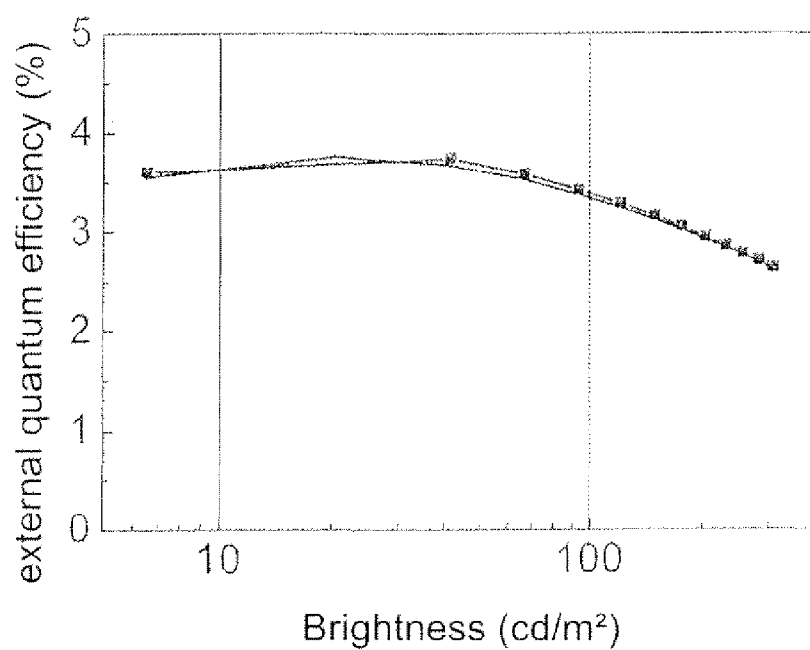


Fig. 6

ELECTRONIC COMPONENT WITH AT LEAST ONE ORGANIC LAYER ARRANGEMENT

[0001] The invention relates to an electronic component, in particular a light-emitting electronic component, having an anode, a cathode and at least one organic layer arrangement, which is arranged between the anode and the cathode and is in electrical contact with the anode and the cathode.

BACKGROUND

[0002] Such electronic components are known in various embodiments. These include for example organic light-emitting components such as organic light-emitting diodes (OLED) organic diodes, organic solar cells and organic transistors. In one embodiment, stacked organic light-emitting components are also known, in which a plurality of individual organic layer arrangements, in particular including a light-emitting zone, are stacked between the anode and the cathode. Thus, for example, OLEDs of stacked structure are known.

[0003] Typically the organic layer arrangement comprises a plurality of superposed organic layers. One or more pn-junctions may also be provided within the organic layer arrangement, as is known in the case of stacked OLEDs (cf. EP 1 478 025 A2), one such pn-junction being formed in one embodiment by means of a p-doped hole transport layer and an n-doped electron transport layer, which are in direct contact with one another. Such a pn-junction constitutes a structure generating electrical charges, in which structure electrical charges are generated, preferably in the boundary zone between the two layers, upon application of an electric potential.

[0004] In organic light-emitting diodes of known structure, when doped charge carrier transport layers are used a p-doped hole transport layer is in contact with the anode or a hole injection layer arranged between the p-doped hole transport layer and the anode. The n-doped electron transport layer is in contact with the cathode or an electron injection layer arranged therebetween.

[0005] When a doped organic layer is formed, one or more doping materials are incorporated into an organic matrix material, this being an organic semiconductor material. A layer is known as a p-doped organic layer if the organic matrix semiconductor material contains dopants in the form of acceptors. A doped layer is known as an n-doped organic layer if the dopants incorporated into the organic matrix material form donors.

[0006] Electrical doping in the sense of the present application takes place in that the one or more incorporated doping materials undergo a redox reaction with the matrix material, whereby an at least partial charge transfer takes place between the one or more doping materials on the one hand and the matrix material on the other, i.e. electrical charges are transmitted between the materials. In this way (additional) free charge carriers are formed in the layer, which for their part increase the electrical conductivity of the layer. A higher density of charge carriers arises in the matrix material compared with undoped material. The following physical interrelationship applies to the electrical conductivity: charge carrier density \times mobility of charge carriers = electrical conductivity. The proportion of the charge carriers in the matrix material that are formed by means of the redox reaction do not have to

be injected from an electrode, but instead such charge carriers are already available in the layer as a result of the electrical doping.

[0007] On the other hand, a semiconductor material is known as a p-type semiconductor material if it is capable of transporting charge carriers in the form of holes, i.e. the mobility for the holes in the semiconductor material is sufficient for transport. Likewise, a semiconductor material is known as an n-type semiconductor material if it is capable of transporting charge carriers in the form of electrons, i.e. the mobility for electrons in the material is sufficient for transport.

[0008] To improve the energetic characteristics in an organic electronic component, it was proposed in document WO 2005/109542 A1 to form a pn-junction with a layer of an n-type organic semiconductor material and a layer of a p-type organic material, the layer of the n-type organic semiconductor material being in contact with an electrode in the form of an anode. This results in improved injection of charge carriers in the form of holes into the layer of p-type organic semiconductor material.

SUMMARY OF THE INVENTION

[0009] The object of the invention is to provide an electronic component having an anode, a cathode and at least one organic layer arrangement between the anode and the cathode with improved operating characteristics.

[0010] This object is achieved according to the invention by an electronic component as claimed in independent claim 1.

[0011] The invention provides an electronic component, in particular a light-emitting electronic component, having an anode, a cathode and at least one organic layer arrangement, which is arranged between the anode and the cathode and is in electrical contact with the anode and the cathode and which comprises at least one of the following zones: a zone which generates electrical charges upon application of an electric potential to the anode and the cathode and has an np-junction, which is formed with a layer of a p-type organic semiconductor material and an n-doped layer of an n-type organic semiconductor material, which is in contact with a conductive layer of the anode, and a zone which generates further electrical charges upon application of the electric potential to the anode and the cathode and has a pn-junction, which is formed with a layer of an n-type organic semiconductor material and a p-doped layer of a p-type organic semiconductor material, which is in contact with a conductive layer of the cathode.

[0012] It has been found that the np-/pn-junction makes it possible efficiently to generate free charge carriers in the organic layer arrangement adjoining one or both electrodes (anode, cathode). Upon application of an electric potential to the anode and the cathode, free charge carriers are generated in particular in the junction zone between the layers forming the junction.

[0013] In comparison with the prior art, the operating voltage is reduced as a result of the conductivity provided by means of doping. In particular it is made possible to vary the thickness of the doped layer of the np-/pn-junction over a wide range without disadvantages arising during transport of the charge carriers.

[0014] Conventional organic light-emitting components suffer from the problem that injection of one charge carrier type, this usually being the electrons, is more difficult than injection of the other charge carrier type, namely the holes. As a result, the balance of charge carrier injection is disturbed. In

many cases this results in the component displaying low current efficiency, since for example unbalanced space charges develop, because charge carriers do not recombine efficiently. In this context, a possible configuration in the form of the use of identical pn-junctions at the cathode and the anode has particular advantages. Due to the similar structure of the two pn-junctions, charge carrier generation proceeds equally efficiently for the provision both of electrons and of holes. This leads to an improvement in the charge carrier balance and thus in the efficiency of light emission in the component.

[0015] Furthermore, the proposed use of pn-junctions allows the use of contact materials which are not feasible in conventional organic light-emitting diodes. Thus, it is possible, for example, to use Au or ITO as the top electrode in the form of a cathode, i.e. during operation of the component this contact is connected with the negative pole of the voltage source. If specific electrode materials are desired for technical reasons, but in conventional component structures incompatibilities arise with regard to the conventional organic materials for charge carrier transport layers, such as for example chemical reactions or the diffusion of atoms or ions, the proposed use of a pn-junction or of two pn-junctions allows greater latitude in the selection of metals or transport materials. It is possible, for example, to use as the anode metals with a low work function of less than 5.1 eV and preferably of less than 4.5 eV, such as for example Al or Ag. Likewise, provision may be made for the metals used as the cathode to have a high work function of greater than 4.2 eV, such as for example Au or ITO. The possibility is additionally provided of using hole transport materials in conjunction with the cathode and or electron transport materials in conjunction with the anode. This makes it simpler to combine suitable compatible contact materials and organic transport materials.

[0016] A significant problem with using organic light-emitting components is that the "inverted" structure is difficult to achieve. With this structure, the cathode is located on the substrate and the anode forms a top contact. Such structures are conventionally distinguished by a markedly higher operating voltage and shorter service life than a similar, non-inverted structure. The use of a pn-junction or of two pn-junctions improves the characteristics of the inverted structure. The reason for this is that the electrode materials used in the non-inverted structures for the anode and the cathode, for example ITO for the anode and Ag or Al for the cathode, may still remain in the same component position, namely as bottom and top contact, but function in conjunction with the pn-junction or the pn-junctions as cathode and anode in an inverted structure.

[0017] For a p-type organic semiconductor material it is advantageous if the mobility for charge carriers in the form of holes is greater than 10^{-7} cm²/Vs and preferably greater than 10^{-5} cm²/Vs. Furthermore, it is advantageous for the doped p-type organic semiconductor material to have a low oxidation potential of less than 0.5V vs. Fc/Fc⁺, preferably of less than 0V vs. Fc/Fc⁺ and more preferably of less than -0.5V vs. Fc/Fc⁺. Finally, it is advantageous for the doped p-type organic semiconductor material to have an electrical conductivity which is greater than 10^{-7} S/cm, preferably greater than 10^{-5} S/cm and more preferably than 10^{-3} S/cm.

[0018] For an n-type organic semiconductor material it is advantageous if the mobility for charge carriers in the form of electrons is greater than 10^{-7} cm²/Vs and preferably greater than 10^{-5} cm²/Vs. Furthermore, it is advantageous for the

doped n-type organic semiconductor material to have a high oxidation potential of greater than -2.5V vs. Fc/Fc⁺, preferably of greater than -2.0V vs. Fc/Fc⁺ and more preferably of greater than -1.5V vs. Fc/Fc⁺. Finally, it is advantageous for the doped n-type organic semiconductor material to have a conductivity which is greater than 10^{-7} S/cm, preferably greater than 10^{-5} S/cm and more preferably greater than 10^{-3} S/cm.

[0019] It is additionally advantageous for the energetic difference between the lowest unoccupied molecular orbital (LUMO) of the material of the n-doped n-type organic semiconductor layer and the highest occupied molecular orbital (HOMO) of an adjoining layer of a p-type organic semiconductor material to be less than 1.5 eV, preferably less than 1.0 eV and more preferably less than 0.5 eV. In a case where the adjoining p-type organic semiconductor layer is likewise doped, it is advantageous for the energetic difference to be less than 2.5 eV, preferably less than 2.0 eV and more preferably less than 1.5 eV.

[0020] In addition or as an alternative, provision may be made for the energetic difference between the HOMO of the p-doped layer of the p-type organic semiconductor material and the LUMO of an adjoining layer of an n-type organic semiconductor material to be less than 1.5 eV, preferably less than 1.0 eV and more preferably less than 0.5 eV. In a case where the adjoining n-type organic semiconductor layer is likewise doped, it is advantageous for the energetic difference to be less than 2.5 eV, preferably less than 2.0 eV and more preferably less than 1.5 eV.

[0021] In a preferred further development of the invention, it is provided that the layer of n-type organic semiconductor material is a further n-doped layer. The n-doping provides free charge carriers in the form of electrons.

[0022] In one convenient configuration of the invention, it may be provided that the layer of p-type organic semiconductor material is a further p-doped layer. The p-doping provides free charge carriers in the form of holes.

[0023] In an advantageous embodiment of the invention it is provided that the layer of p-type organic semiconductor material is formed as at least one layer type selected from the following group of layer types: hole transport layer and electron blocking layer. A hole transport layer is characterized in that it is formed with sufficient hole mobility for transport of the holes. In one simple embodiment the layer of p-type organic semiconductor material is an electron blocking layer, with which the transport of electrons in the direction of the anode is stopped, whilst charge carriers in the form of holes are transported. These characteristics are based on different energetic barriers for the transport of electrons and holes in the electron blocking layer.

[0024] Preferably, in a further development of the invention it is provided that the layer of n-type organic semiconductor material is formed as at least one layer type selected from the following group of layer types: electron transport layer and hole blocking layer. An electron transport layer is characterized in that it is formed with sufficient electron mobility for transport of the electrons. In one simple embodiment, the layer of n-type organic semiconductor material, which is for its part in contact with the conductive layer of the cathode, is a hole blocking layer, with which the transport of charge carriers is blocked in the organic layer arrangement in the direction away from the cathode, whilst electric charge carriers in the form of electrons are passed on. These character-

istics are based on different energetic barriers for the transport of electrons and holes in the hole blocking layer.

[0025] In an advantageous configuration of the invention it may be provided that the at least one organic layer arrangement comprises a light-emitting zone which is optionally of single-layer or multilayer construction. In the light-emitting zone the free charge carriers, namely electrons and holes, recombine, emitting light. In the light-emitting zone one or more emitter materials may be arranged, these being capable of outputting different-colored light in the case of a plurality of emitter materials, whereby overall white light is preferably generated.

[0026] In a convenient configuration of the invention, it may be provided that the layer of p-type organic semiconductor material is formed as part of the light-emitting zone. Within the organic layer arrangement, the light-emitting zone then directly adjoins the n-doped layer of the n-type organic semiconductor material.

[0027] Preferably, in a further development of the invention it is provided that the layer of n-type organic semiconductor material is formed as part of the light-emitting zone. Within the organic layer arrangement, the light-emitting zone then directly adjoins the p-doped layer of the p-type organic semiconductor material.

[0028] In a convenient further development of the invention it is provided that the layer of n-type organic semiconductor material is of multi layer construction.

[0029] In an advantageous configuration of the invention, it may be provided that the layer of p-type organic semiconductor material is of multilayer construction.

[0030] In a preferred further development of the invention it is provided that the p-type organic semiconductor material of the p-doped layer of p-type organic semiconductor material is an organic semiconductor material selected from the following group of organic semiconductor materials: triarylamine, phthalocyanine, an organometallic complex compound such as cobaltocene, a metal complex such as $\text{Cr}(\text{hpp})_4$, a free radical such as pentaphenylcyclopentadienyl and an organic reducing agent such as tetrathiafulvalene derivatives or amino-substituted polycycles.

[0031] In a convenient configuration of the invention it may be provided that the electronic component is implemented as a component selected from the following group of components: organic light-emitting component, organic diode, organic solar cell, organic transistor and organic light-emitting diode.

[0032] Provision may additionally be made for the insertion between the layers consisting of the p-doped p-type organic semiconductor material and the n-type organic semiconductor material or the n-doped n-type organic semiconductor material and the p-type organic semiconductor material of a thin interlayer. Such an interlayer may consist for example of a metal or of acceptors and/or donors. The interlayer leads in particular to an improvement in the stability of the pn-junction.

[0033] Provision may conveniently be made for the n-type organic semiconductor material of the n-doped layer of n-type organic semiconductor material to be an organic semiconductor material selected from the following group of organic semiconductor materials: C60 fullerenes, hexaazat-

riphenylenes, in particular hexanitrile hexaazatriphenylene, and 1,3,4,5,7,8-hexafluoronaphtho-2,6-quinone tetracyanomethane.

DESCRIPTION OF THE EMBODIMENTS OF THE INVENTION

[0034] The invention is explained in greater detail below by means of exemplary embodiments with reference to the Figures in the drawings, in which:

[0035] FIG. 1 is a schematic representation of an organic electronic component, in which, between an electrode and a counter-electrode, there is arranged an organic layer arrangement in contact with the electrode and the counter-electrode;

[0036] FIG. 2 is a graphic representation of current density as a function of voltage for various exemplary embodiments of an organic electronic component;

[0037] FIG. 3 is a graphic representation of luminance as a function of voltage for the various embodiments of the organic electronic component;

[0038] FIG. 4 is a graphic representation of current efficiency as a function of luminance for the various embodiments of the organic electronic component;

[0039] FIG. 5 is a graphic representation of current density and brightness as a function of voltage for an Example 10 of an organic electronic component; and

[0040] FIG. 6 is a graphic representation of external quantum efficiency as a function of brightness for Example 10.

[0041] FIG. 1 is a schematic representation of an organic electronic component, in which, between an electrode 1 and a counter-electrode 2, which is formed on a substrate 3, there is arranged an organic layer arrangement 4, which is for its part in electrical contact with the electrode 1 and the counter-electrode 2. An electrical voltage may be applied to the organic layer arrangement 4 via the electrode 1 and the counter-electrode 2, which are formed by an anode and a cathode. In the case of embodiment as a light-emitting organic electronic component, application of the electrical voltage leads to free charge carriers, namely electrons and holes, migrating within the organic layer arrangement 4 to a light-emitting zone and there recombining while emitting light.

[0042] In the following description of preferred exemplary embodiments the following stated abbreviations are used: ETL—electron transport layer, HTL—hole transport layer, EBL—electron blocking layer, HBL—hole blocking layer and EL—light-emitting zone.

[0043] The organic layer arrangement 4 in the organic electronic component illustrated in FIG. 1 may be built up in a layer structure with different configurations. The layer arrangements stated below are advantageous:

[0044] anode/n-doped ETL/p-doped HTL/EBL/EL/HBL/n-doped ETL/p-doped HTL/cathode

[0045] anode/n-doped ETL/p-doped HTL/EBL/EL/HBL/n-doped ETL/cathode.

[0046] anode/p-doped HTL/EBL/EL/HBL/n-doped ETL/p-doped HTL/cathode.

[0047] anode/n-doped ETL/EBL/EL/HBL/p-doped HTL/cathode

[0048] anode/n-doped ETL/EBL/EL/HBL/n-doped ETL/cathode

[0049] anode/p-doped HTL/EBL/EL/HBL/p-doped HTL/cathode

[0050] cathode/p-doped HTL/n-doped ETL/HBL/EL/EBL/p-doped HTL/n-doped ETL/anode

[0051] cathode/n-doped ETL/HBL/EL/EBL/p-doped HTL/n-doped ETL/anode

[0052] cathode/p-doped HTL/n-doped ETL/HBL/EL/EBL/p-doped HTL/anode

[0053] cathode/p-doped HTL/HBL/EL/EBL/n-doped ETL/anode

[0054] cathode/n-doped ETL/HBL/EL/EBL/n-doped ETL/anode

[0055] cathode/p-doped HTL/HBL/EL/EBL/p-doped HTL/anode

[0056] In some embodiments the layers HBL and/or EBL may be omitted, for example when the layer EL is of electron-transporting/hole-transporting construction.

[0057] In the stated embodiments, at least one pn-/np-junction is always formed, in which, upon application of an electrical voltage to the two electrodes, charge carriers are generated, namely electrons and holes. The above-stated embodiments of the organic layer arrangement 4 may also be combined together in any desired way, such that two junctions may also be formed in the organic layer arrangement 4. In each case including at least one pn-/np-junction, one or more charge-generating zones or charge-generating layers are thus formed, for example: anode/n-doped ETL/EBL/EL/HBL/p-doped HTL/cathode or anode/n-doped ETL/p-doped HTL/EBL/EL/HBL/n-doped ETL/p-doped HTL/cathode.

[0058] It has been found that in a simple embodiment efficient charge generation takes place between the n-doped ETL and the EBL. Likewise, charge generation has been observed between the p-doped HTL and the HBL.

[0059] In simple embodiments it is advantageous for the energetic difference between the lowest unoccupied molecular orbital (LUMO) of the material of the n-doped ETL and the highest occupied molecular orbital (HOMO) of the material of the EBL to be less than 1.5 eV, preferably less than 1.0 eV and more preferably less than 0.5 eV.

[0060] In addition or as an alternative, provision may be made for the energetic difference between the HOMO of the material of the p-doped HTL and the LUMO of the material of the HBL to be less than 1.5 eV, preferably less than 1.0 eV and more preferably less than 0.5 eV.

[0061] Examples of organic electronic components constructed as illustrated schematically in FIG. 1 and with different structures of the organic layer arrangement 4 are explained below in greater detail. The components were produced by depositing the materials as a layer stack, the conventional technology of vacuum evaporation being used.

[0062] In the Examples described below, the following abbreviations are used: ITO—indium-tin oxide; Al—aluminum; STTB—2,7-tetra-(di-p-tolylamine)-9,9'-spirobi fluoren; Pdop—1,3,4,5,7,8-hexafluoronaphtho-2,6-quinone tetracyanomethane; NPB—N,N'-bis(naphthalen-2-yl)-N,N'-diphenylbenzidine; Ndop—tetrakis(1,2,3,3a,4,5,6,6a,7,8-decahydro-1,9,9b-triazaphenalenyl)ditungsten(II); ETM—2,4,7,9-tetraphenyl phenanthroline; ORE—iridium(III) bis(2-methylbenzo-[f,h]quinoxaline)(acetylacetonate); HTM—tris(1-phenylisoquinoline) iridium(III); BPhen—bathophenanthroline, HAT—hexanitrile hexaazatriphenylene

[0063] P-dop has a reduction potential of approx. +0.2V vs. Fc/Fc⁺. NPB—has an oxidation potential of approx. 0.3V vs. Fc/Fc⁺. Ndop has an oxidation potential of approx. -2.2V vs. Fc/Fc⁺. ETM has a reduction potential of approx. -2.2V vs. Fc/Fc⁺. HTM has an oxidation potential of approx. 0.2 V vs. Fc/Fc⁺. Fullerene C60 has a reduction potential of approx.

-1V vs. Fc/Fc⁺. STTB has an oxidation potential of approx. 0.1V vs. Fc/Fc⁺. HAT has a reduction potential of approx. -0.6V vs. Fc/Fc⁺.

[0064] With regard to the different structures, the abbreviations below have the following general meanings: "p"—a p-doped layer, "i"—an undoped layer (insulator) and "n"—an n-doped layer.

Example 1

[0065] As Example 1 an organic electronic component was produced as reference with a conventional pin structure. The component comprises the following layer structure: substrate: glass/anode: 90 nm ITO/p-doped layer: 50 nm Pdop in STTB (1.5 weight percent)/intrinsic layer: 10 nm NPB/intrinsic EL: 20 nm ORE in NPB (10%)/intrinsic interlayer: 10 nm ETM/n-doped layer: 55 nm Ndop in ETM (8 weight percent)/cathode: 100 nm Al.

Example 2

[0066] As Example 2 an organic electronic component was produced with an npin structure: glass/anode: 90 nm ITO/45 nm Ndop in ETM (8 weight percent)/5 nm Pdop in HTM (1.5 weight percent)/10 nm NPB/20 nm ORE in NPB (10%)/10 nm ETM/55 nm Ndop in ETM (8 weight percent)/100 nm Al. The conductivity of the layer of Ndop in ETM amounts to approx. $2 \cdot 10^{-5}$ S/cm

Example 3

[0067] As a further Example 3, an organic electronic component was produced with the following pinp layer structure: glass/anode: 90 nm ITO/50 nm Pdop in STTB (1.5 weight percent)/10 nm NPB/20 nm ORE in NPB (10%)/10 nm ETM/55 nm Ndop in ETM (8 weight percent)/5 nm Pdop in HTM (1.5 weight percent)/100 nm Al. The conductivity of the layer of Pdop in HTM amounts to approx. $4 \cdot 10^{-5}$ S/cm

Example 4

[0068] In addition, an organic electronic component with the following layer structure (npin) was produced as Example 4: glass/anode: 90 nm ITO/45 nm Ndop in ETM (8 weight percent)/5 nm Pdop in HTM (1.5 weight percent)/10 nm NPB/20 nm ORE in NPB (10%)/10 nm ETM/55 nm Ndop in ETM (8 weight percent)/5 nm Pdop in HTM (1.5 weight percent)/100 nm Al.

Example 5

[0069] In addition, an organic electronic component with the following layer structure (pnipn) was produced as Example 5: glass/90 nm ITO/5 nm Pdop in HTM (1.5 weight percent)/45 nm Ndop in ETM (8 weight percent)/10 nm ETM/20 nm ORE in NPB(10%), 10 nm NPB/5 nm Pdop in the HTM (1.5 weight percent)/55 nm Ndop in ETM (8 weight percent)/anode: 100 nm Al

Example 6

[0070] As Example 6 an organic electronic component was produced with a simplified structure as follows: glass/anode: ITO/1,3,4,5,7,8-hexafluoronaphtho-2,6-quinone tetracyanomethane doped with Ndop(50 nm)/NPd:ORE (20 nm, 10 weight percent)/BPhen (10 nm)/BPhen:Cs (8:1, 60 nm)/Al. A current density of 10 mA/cm² was measured at an operating voltage of 2.8V. The electrical conductivity of the layer of

1,3,4,5,7,8-hexafluoronaphtho-2,6-quinonetetracyanomethane doped with Ndop amounts to approx. $g \cdot 10^{-5}$ S/cm

Example 7

[0071] As Example 7 a structure was produced for the purposes of comparison: glass anode: ITO/1,3,4,5,7,8-hexafluoronaphtho-2,6-quinonetetracyanomethane (50 nm)/NPD); ORE (20 nm, 10 weight percent)/BPhen (10 nm)/BPhen: Cs (60 nm) Al. A current density of 10 mA/cm^2 was measured at an operating voltage of 3.3V.

Example 8

[0072] As Example 8 an organic electronic component was produced with a simplified structure as follows: glass/anode: ITO/HAT doped with Ndop(50 nm)/NPD); ORE (20 nm, 10 weight percent)/BPhen (10 nm)/BPhen:Cs (8:1, 60 nm)/Al. A current density of 10 mA/cm^2 was measured at an operating voltage of 4.4V. The conductivity of the HAT layer doped with Ndop amounts to approx. $5 \cdot 10^{-5}$ S/cm

Example 9

[0073] As Example 9 an organic electronic component was additionally produced with the following layer structure:

- [0074] 1. transparent glass substrate
- [0075] 2. metal strips, spacing $450 \mu\text{m}$ (anode)
- [0076] 3. fullerene layer doped with organic donor-type molecules
- [0077] 4. discontinuous gold layer, average thickness 1 nm
- [0078] 5. hole transport layer
- [0079] 6. electron blocking layer
- [0080] 7. light-emitting layer
- [0081] 8. hole blocking layer
- [0082] 9. electron transport layer
- [0083] 10. aluminum cathode

[0084] Layers 3 and 5, namely the fullerene layer doped with organic donor-type molecules and the hole transport layer, form a pn-junction, the layer 4 being arranged as a stabilizing metal layer between these two layers.

Example 10

[0085] In addition, an organic electronic component with the following layer structure was produced as Example 10:

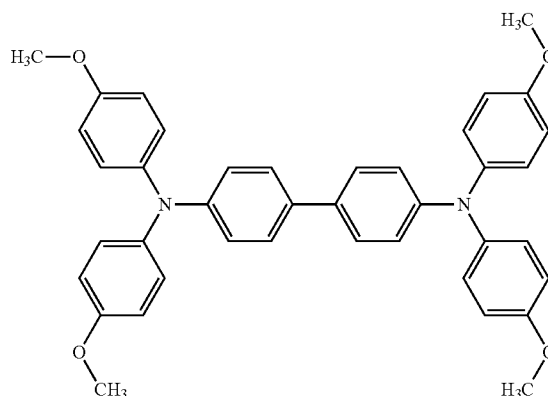
- [0086] transparent glass substrate
- [0087] chromium strips, spacing $450 \mu\text{m}$, width $50 \mu\text{m}$, thickness 10 nm (anode)
- [0088] 30 nm C60 doped with 2 mol % $[\text{Ru}(\text{t-butyl-trpy})_2]0$
- [0089] nominally 1 nm gold (discontinuous layer)
- [0090] 95 nm MeO-TPD doped with 4 mol % F4-TCNQ
- [0091] 10 nm Spiro-TAD
- [0092] 20 nm BAlq doped with 20 wt. % $\text{Ir}(\text{piq})_3$
- [0093] 10 nm BPhen
- [0094] 65 nm BPhen doped with Cs
- [0095] 100 nm Al (cathode)

[0096] In this exemplary embodiment the layers 22 and 24 form a pn-junction, the layer 23 of gold being provided between the two layers as a stabilizing metal layer, which is for its part discontinuous. The electrical conductivity of the layer 22 was less than 0.5 S/cm. FIGS. 5 and 6 show data relating to Example 10.

[0097] In Examples 9 and 10 a doped layer of fullerene is used in each case. Fullerenes, in particular Buckminsterfullerene C60, have been the subject of intensive research since their discovery in 1985 and are used for example in organic solar cells as an acceptor material (cf. U.S. Pat. No. 6,580,027 B2). Document WO 92/04279 discloses a method for the production of C60 and C70 in relatively large quantities. These days fullerenes are available as inexpensive starting materials. As WO 2005/086251 A2 explains, C60 fullerenes, combined with dopants, have conductivities of over 2 S/cm. The layer made from fullerene is preferably applied under a high vacuum by means of simultaneous evaporation of the fullerene and of the organic dopant, i.e. using the method conventional for organic thin layers. Thus the application of such a fullerene layer fits without additional expenditure into the production process for the organic light-emitting component.

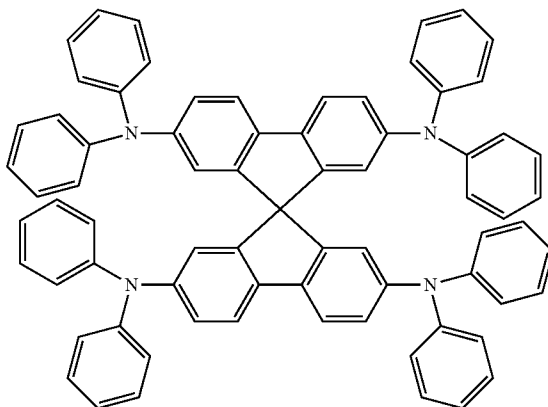
[0098] Organic materials which were used or may be provided in preceding Examples 9 or 10 are listed in the following Table:

MeO-TPD
N,N,N',N'-tetrakis(4-methoxyphenyl)-benzidine

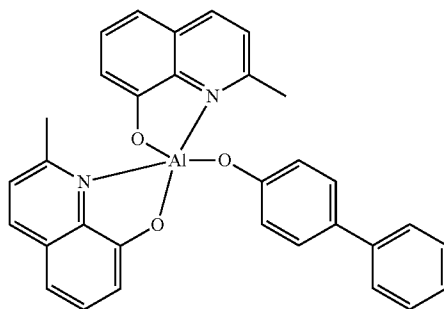


-continued

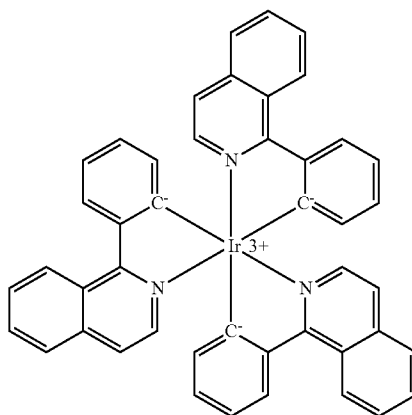
Spiro-TAD
2,2',7,7'-tetrakis-(N,N-
diphenylamino)-9,9'-
spirobifluorene



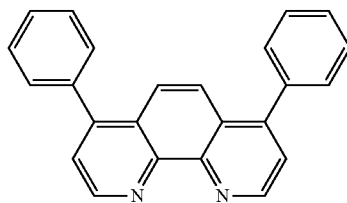
BAlq
Bis-(2-methyl-8-quinolinolato)-4-
(phenyl-phenolato)-aluminum-(III)



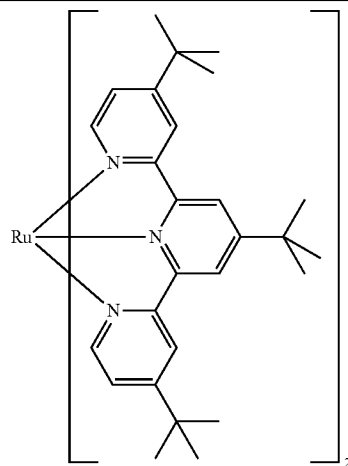
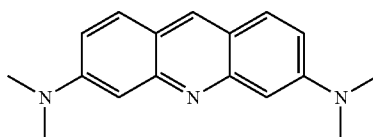
Ir(piq)₃
tris(1-phenylisoquinoline)iridium



Bphen
4,7-diphenyl-1,10-phenanthroline



-continued

[Ru(t-butyl-trpy)₂]⁰AOB
acridine orange base

Example 11

[0099] In addition, an organic electronic component with the following layer structure (nip) was produced as Example 11 for comparison purposes: cathode ITO/75 nm ETM doped with Ndop (9 weight percent)/10 nm ETM/20 nm BALq doped with Ir(pic)3 (10 weight percent)/10 nm NPB/45 nm STTB doped with Pdop (6 weight percent) anode 100 nm Al. In this case, the cathode of ITO is located on a transparent glass substrate.

Example 12

[0100] In addition, an organic electronic component with the following layer structure (nipn) was produced as Example 12: cathode ITO/75 nm ETM doped with Ndop (9 weight percent)/10 nm ETM/20 nm BALq doped with Ir(pic)3 (10 weight percent)/10 nm NPB/20 nm STTB doped with Pdop (6 weight percent)/25 nm ETM doped with Ndop (9 weight percent)/anode 100 nm Al. In comparison with Example 11, a low operating voltage and a relatively high current efficiency were measured in the case of use of a p-junction in conjunction with the anode.

Example 13

[0101] An organic electronic component with the following layer structure was produced: anode: 90 nm ITO/50 nm Pdop in STTB (1.5 weight percent)/10 nm NPB/20 nm ORE in NPB (10%)/10 nm ETM/10 nm Ndop in ETM (8 weight percent)/5 nm Pdop in HTM (1.5 weight percent)/40 nm Pdop in STTB (1.5 weight percent)/100 nm Al. The p-doped p-type layer is here of multilayer construction, so as to improve the stability of the component.

[0102] FIG. 2 is a graphic representation of current density as a function of voltage for various exemplary embodiments of an organic component.

[0103] FIG. 3 is a graphic representation of luminance as a function of voltage for the various embodiments of the organic electronic component.

[0104] FIG. 4 is a graphic representation of current efficiency as a function of luminance for the various embodiments of the organic electronic component.

[0105] The features of the invention disclosed in the above description, claims and drawings may be of significance in implementation of the invention in its various embodiments either individually or in any desired combination.

1. An electronic component, in particular a light-emitting electronic component having an anode, a cathode and at least one organic layer arrangement, which is arranged between the anode and the cathode and is in electrical contact with the anode and the cathode and which comprises at least one of the following zones:

a zone which generates further electrical charges upon application of the electric potential to the anode and the cathode and has a pn-junction, which is formed with a layer of an n-type organic semiconductor material and a p-doped layer of a p-type organic semiconductor material, which is in contact with a conductive layer of the cathode.

2. The component according to claim 1, characterized in that the layer of n-type organic semiconductor material is a further n-doped layer.

3. The component according to claim 1 or claim 2, characterized in that the layer of p-type organic semiconductor material is a further p-doped layer.

4. The component according to any one of the preceding claims, characterized in that the layer of n-type organic semiconductor material is formed as at least one layer type selected from the following groups of layer types: electron transport layer and hole blocking layer.

5. The component according to any one of the preceding claims, characterized in that the layer of p-type organic semi-

conductor material is formed as at least one layer type selected from the following groups of layer types: hole transport layer and electron blocking layer.

6. The component according to any one of the preceding claims, characterized in that the at least one organic layer arrangement comprises an optionally single-layer or multi-layer light-emitting zone.

7. The component according to claim 6, characterized in that the layer of p-type organic semiconductor material is formed as part of the light-emitting zone.

8. The component according to claim 6 or claim 7, characterized in that the layer of n-type organic semiconductor material is formed as part of the light-emitting zone.

9. The component according to any one of the preceding claims, characterized in that the layer of n-type organic semiconductor material is of multilayer construction.

10. The component according to any one of the preceding claims, characterized in that the layer of p-type organic semiconductor material is of multilayer construction.

11. The component according to any one of the preceding claims, characterized in that the p-type organic semiconductor material of the p-doped layer is an organic semiconductor material selected from the following group of organic semiconductor materials: triarylamine, phthalocyanine, an organometallic complex compound such as cobaltocene, a metal complex such as $\text{Cr}(\text{hpp})_4$, a free radical such as pentaphenylcyclopentadienyl and an organic reducing agent such as tetrathiafulvalene derivatives or amino-substituted polycycles.

12. The electronic component according to any one of the preceding claims, implemented as a component selected from the following group of components: organic light-emitting component, organic diode, organic solar cell, organic transistor and organic light-emitting diode.

* * * * *