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(54) Title: FLAT PANEL OLED DEVICE HAVING DEFORMABLE SUBSTRATE

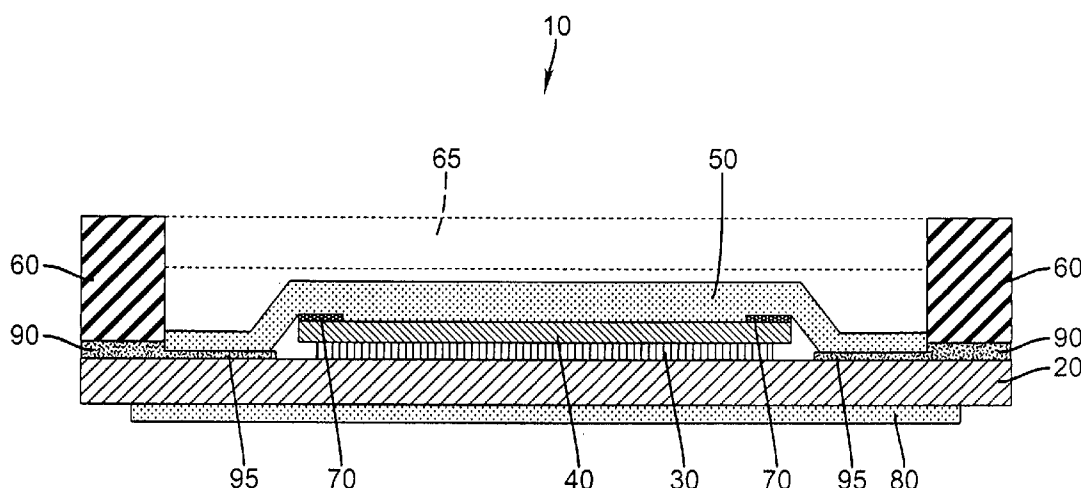


FIG. 1

(57) Abstract: A flat panel OLED device including a transparent deformable substrate having first and second sides and defining a predetermined illumination region and a non-illumination region; a moisture-sensitive OLED disposed over the first side of the transparent substrate within the illumination region and means for applying electrical signals to the OLED which causes the OLED to produce light and heat; a protective layer disposed over the OLED; a flexible encapsulating foil disposed over the protective layer, but not attached thereto, and which dissipates the heat and sealingly connected to the substrate in the non-illumination region; and a rigid chassis structure operatively associated with the transparent deformable substrate for providing rigidity to the transparent deformable substrate.

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FLAT PANEL OLED DEVICE HAVING DEFORMABLE SUBSTRATE**FIELD OF THE INVENTION**

The present invention relates to flat panel OLED devices and more particularly to structures for providing rigidity to such devices and for protecting
5 them from moisture damage.

BACKGROUND OF THE INVENTION

Organic light-emitting diode (OLED) devices initially found acceptance as relatively small display devices. Typically OLED devices have a hole-transporting layer and electron-transporting layer disposed on either side of a
10 organic light-emitting layer. Spaced electrodes cause current to pass through the OLED, and the combination of holes and electrons in the organic light-emitting layer produces light. These OLED devices typically have either a passive-matrix or active-matrix drive format. Flat-panel devices, such as television displays, presentation displays, or light-emitting panels, are becoming more popular. Flat-
15 panel OLED devices offer a number of advantages for these applications.

However, there are problems associated with flat-panel OLED devices. To reduce weight, OLED devices typically use a thin, deformable substrate that can bend, fracture, or break, thereby distorting the light output. Another difficulty is that if the substrate is thin, the OLED can produce enough heat to distort the substrate.

20 Various methods have been used to provide support for OLED devices. Guenther, in U.S. Patent No. 6,660,547, discloses a support rim for electroluminescent devices. Heimgartner, in U.S. Patent No. 6,688,933, teaches the use of a structural frame for electroluminescent devices. Guenther et al., in U.S. Patent No. 7,026,758, disclose a stiff reinforcement lid for an
25 electroluminescent device, wherein the lid serves to support the device. In none of these cases, however, is any provision made for removing heat.

Kikuchi et al., in U.S. Patent No. 7,063,902, teach an OLED that has been encapsulated with a filler layer that is heat-conductive. However, there is no indication of how to provide such a heat-conductive layer with support. In
30 JP 10-275681, there is shown a protecting layer with a metal filler and carbon powder to provide high heat conductance.

It is thus a problem to be solved to provide both structural support and heat dissipation to an electroluminescent device.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a flat
5 panel OLED device that provides rigidity to the transparent deformable substrate and that also provides moisture and heat protection for the OLED in the flat panel device.

This object is achieved by a flat panel OLED device comprising:

(a) a transparent deformable substrate having first and second
10 sides and defining a predetermined illumination region and a non-illumination region;

(b) a moisture-sensitive OLED disposed over the first side of the transparent substrate within the illumination region and means for applying electrical signals to the OLED which causes the OLED to produce light and heat;

15 (c) a protective layer disposed over the OLED;

(d) a flexible encapsulating foil disposed over the protective layer, but not attached thereto, and which dissipates the heat; and

(e) a rigid chassis structure operatively associated with the transparent deformable substrate for providing rigidity to the transparent
20 deformable substrate.

It is an advantage of this invention that it provides for heat distribution and reduces the risk of overheating and heat-distortion of an OLED device, and greatly reduces the risk of image burn-in. It is a further advantage of this invention that it also provides structural support for an OLED device,
25 providing excellent rigidity for large pieces of OLED glass, and can provide a robust mounting structure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a cross-sectional view of a first embodiment of a flat-panel OLED device with a rigid chassis structure according to this invention;

30 FIG. 2 shows a top view of the rigid chassis structure of FIG. 1;

FIG. 3 shows a cross-sectional view of a flexible encapsulating foil useful in the OLED device of this invention; and

FIG. 4 shows a cross-sectional diagram representing the structure of a prior-art OLED that is useful with the present invention.

5 **DETAILED DESCRIPTION OF THE INVENTION**

The term "OLED display", or "organic light-emitting display" is used in its art-recognized meaning of a display device comprising organic light-emitting diodes as pixels. The term "OLED device" refers to a light-emitting device comprising organic light-emitting diodes, but is not limited to a display
10 device, e.g. "OLED device" can include illuminating panels. The term "multicolor" is employed to describe a display panel that is capable of emitting light of a different hue in different areas. In particular, it is employed to describe a display panel that is capable of displaying images of different colors. These areas are not necessarily contiguous. The term "full color" is commonly employed to
15 describe multicolor display panels that are capable of emitting in at least the red, green, and blue regions of the visible spectrum and displaying images in any combination of hues. The complete set of colors that can be generated by a given display is commonly called the color gamut of the display. The red, green, and blue colors constitute the three primary colors from which all other colors can be
20 generated by appropriate mixing. However, the use of additional colors to extend the color gamut or within the color gamut of the device is possible. The term "hue" refers to the intensity profile of light emission within the visible spectrum, with different hues exhibiting visually discernible differences in color. The term "pixel" is employed in its art-recognized usage to designate an area of a display
25 panel that can be stimulated to emit light independently of other areas.

Turning now to FIG. 1, there is shown a cross-sectional view of a first embodiment of a flat-panel OLED device 10 with a rigid chassis structure according to this invention. OLED device 10 includes a substrate 20, which is a transparent deformable substrate through which light is emitted. OLED device 10
30 is thus of the type commonly known as a bottom-emitting OLED. OLED device 10 can be a flat panel OLED display, e.g. an OLED device that can display images

in one or more colors, including a full-color display. Such a display can include an array of addressable OLED pixels as well-known in the art. The array of pixels can be a passive-matrix array or an active-matrix array. In the case of an active-matrix array, an array of electronic control elements, e.g. thin-film transistors (TFTs) can be patterned onto substrate 20 for controlling the emission intensity of individual pixels. Alternatively, OLED device 10 can be an illuminating device, e.g. a lighting panel. A moisture-sensitive OLED 30 as well-known in the art is disposed over the first side of transparent substrate 20. In the embodiment wherein OLED device 10 is an OLED display, OLED 30 includes an array of moisture-sensitive, addressable OLED pixels as well-known in the art. OLED device 10 includes an illumination region and a non-illumination region. In the most basic embodiment, the illumination region is defined by OLED 30 or a portion thereof, while the area on substrate 20 surrounding OLED 30 defines the non-illumination region. It will be understood that other embodiments are possible; for example, an OLED device can have multiple non-contiguous illumination regions separated by non-illumination regions. In the embodiment wherein OLED device 10 is an OLED display, the illumination and non-illumination regions are commonly known as the display and non-display regions, respectively. OLED device 10 also includes electrical conductors connected to a power source for applying electrical signals to OLED 30, which causes the OLED to produce light, and also thereby produces unwanted heat.

A protective layer 40, which is desirably electrically insulating, is disposed over OLED 30. Protective layer 40 protects OLED 30 from electrical short-circuits and from physical damage from contact, e.g. rubbing, due to a conductive foil layer disposed over it, as described below. Some examples of materials for protective layer 40 include a polymer, and an oxide layer, e.g. SiO_x . Protective layer 40 can be from 0.5 to 25 microns thick. Protective layer 40 extends past the edge of OLED 30 based upon normal manufacturing tolerances, so as to completely cover the cathode of OLED 30.

OLED device 10 further includes a flexible encapsulating foil 50. Foil 50 is disposed over protective layer 40, but is not attached thereto. Foil 50 is

sealingly connected to the non-illumination region of substrate 20 with an adhesive 95 at or near the edge of the foil 50, thus creating a seal enclosing OLED 30. Adhesive 95 has a low permeability to moisture, and typically is provided with a width of 0.5 to 15 mm and a thickness of 5 to 50 microns. A desiccant layer 70 can further be placed over the periphery of protective layer 40 and between protective layer 40 and foil 50. Some non-limiting examples of desiccants include alumina, bauxite, calcium sulfate, clays, silica gel, zeolites, alkaline metal oxides, alkaline earth oxides, sulfates, metal halides, and perchlorates. FIG. 2 shows a cross-sectional view of a flexible encapsulating foil useful in the OLED device of this invention. Foil 50 can be a metal foil such as aluminum foil, a metal-coated polymer sheet, or a multi-layer laminated foil including a polymer layer 130, a graphite layer 140, and a layer of aluminum foil 150. One example of the latter material is eGraf, which is commercially available from GrafTech. Such a structure has good thermal conductivity in its plane and dissipates heat from OLED 30. The aluminum foil layer is placed closest to protective layer 40.

OLED device 10 further includes rigid chassis structure 60 that is operatively associated with substrate 20 via connection by means of a structural adhesive 90 in the non-illumination region of substrate 20. Adhesive 90 can be a structural foam tape or a dispensable adhesive. It is desirable to have adhesive 90 around the entire perimeter of chassis structure 60, but gaps can be left as needed for wire access, etc. Chassis structure 60 is an open frame structure that provides rigidity and support to substrate 20. Rigid chassis structure 60 is spaced from foil 50 in the illumination region such that chassis structure 60 does not touch foil 50 while maintaining a display as thin as possible, e.g. a 5 mm gap. Chassis structure 60 is formed from a material that provides rigidity and is lightweight, e.g. a metal such as aluminum. The open structure of chassis structure 60, including a frame at the periphery of substrate 20 held rigid by cross-braces 65, which are indicated in FIG. 1 by a dotted-line structure, allows foil 50 to dissipate heat from OLED 30. Chassis structure 60 can be formed using any of a variety of methods well-known

for making such structures, so that chassis structure 60 can be e.g. an aluminum cast structure, a stamped sheet metal structure, or a tubular weldment structure.

OLED device 10 can also include a transparent plastic sheet 80 sealingly attached to the second side of substrate 20, e.g. by adhesive in the non-illumination region of substrate 20. Such sheet 80 can be optically functional, e.g. a polarizing sheet. This sheet 80 can also provide added protection against damage to substrate 20.

Turning now to FIG. 3, there is shown a top view of the rigid chassis structure 60 of FIG. 1. FIG. 3 shows the open frame structure of chassis structure 60. Cross-braces 65 provide support and rigidity to the chassis structure 60.

In a preferred embodiment, the invention is employed in a display that includes Organic Light Emitting Diodes (OLEDs) which are composed of small molecule or polymeric OLEDs as disclosed in but not limited to U.S. Patent No. 4,769,292, by Tang et al., and U.S. Patent No. 5,061,569, by VanSlyke et al. Many combinations and variations of organic light emitting displays can be used to fabricate such a display.

General Display Architecture

The present invention can be employed in most bottom-emitting OLED display configurations. These include very simple structures including a single anode and cathode to more complex displays, such as passive matrix displays includes orthogonal arrays of anodes and cathodes to form light emitting elements, and active-matrix displays where each light emitting element is controlled independently, for example, with thin film transistors (TFTs).

There are numerous configurations of the organic layers wherein the present invention can be successfully practiced. A cross-sectional view of a typical prior art structure useful with the present invention is OLED 30, which is shown in FIG. 4 and includes an anode 103, a hole-injecting layer 105, a hole-transporting layer 107, a light-emitting layer 109, an electron-transporting layer 111, and a cathode 113 on substrate 20. These layers are described in detail below. Note that the cathode 113 can alternatively be located adjacent to the

substrate 20, or the substrate 20 can actually constitute the anode 103 or cathode 113. The organic layers between the anode 103 and cathode 113 are conveniently referred to as the organic EL element. The total combined thickness of the organic layers is preferably less than 500 nm.

5 Anode 103 and cathode 113 of OLED 30 are connected to a power source 250 through electrical conductors 260 so as to apply electrical signals to OLED 30 to produce light. The OLED is operated by applying a potential between the anode 103 and cathode 113 such that the anode 103 is at a more positive potential than the cathode 113. Holes are injected into the organic EL
10 element from the anode 103 and electrons are injected into the organic EL element at the cathode 113. Enhanced display stability can sometimes be achieved when the OLED is operated in an AC mode where, for some time period in the cycle, the potential bias is reversed and no current flows. An example of an AC-driven OLED is described in U.S. Patent No. 5,552,678.

15 Substrate

 The OLED display of this invention is typically provided over a supporting substrate where either the cathode or anode can be in contact with the substrate. The electrode in contact with the substrate is conveniently referred to as the bottom electrode. Conventionally, the bottom electrode is the anode, but this
20 invention is not limited to that configuration. The substrate can be any transmissive material including, but not limited to, glass and plastic. The substrate is deformable, by which it is meant that it is not rigid and provides no structural benefit, e.g. glass of 1 mm thickness or less.

Anode

25 Anode 103 should be transparent or substantially transparent to the emission of interest. Common transparent anode materials used in this invention are indium-tin oxide (ITO), indium-zinc oxide (IZO) and tin oxide, but other metal oxides can work including, but not limited to, aluminum-or indium-doped zinc oxide, magnesium-indium oxide, and nickel-tungsten oxide. In addition to these
30 oxides, metal nitrides, such as gallium nitride, and metal selenides, such as zinc selenide, and metal sulfides, such as zinc sulfide, can be used as the anode. Typical anode materials have a work function of 4.1 eV or greater. Desired anode

materials are commonly deposited by any suitable means such as evaporation, sputtering, chemical vapor deposition, or electrochemical means. Anodes can be patterned using well-known photolithographic processes. Optionally, anodes can be polished prior to application of other layers to reduce surface roughness so as to minimize shorts or enhance reflectivity.

Hole-Injecting Layer (HIL)

While not always necessary, it is often useful to provide a hole-injecting layer 105 between anode 103 and hole-transporting layer 107. The hole-injecting material can serve to improve the film formation property of subsequent organic layers and to facilitate injection of holes into the hole-transporting layer. Suitable materials for use in the hole-injecting layer include, but are not limited to, porphyrinic compounds as described in U.S. Patent No. 4,720,432, plasma-deposited fluorocarbon polymers as described in U.S. Patent No. 6,208,075, and some aromatic amines, for example, m-MTDATA (4,4',4''-tris[(3-methylphenyl)phenylamino]triphenylamine). Alternative hole-injecting materials reportedly useful in organic EL displays are described in EP 0 891 121 A1 and EP 1 029 909 A1.

Hole-Transporting Layer (HTL)

Hole-transporting layer 107 contains at least one hole-transporting compound such as an aromatic tertiary amine, where the latter is understood to be a compound containing at least one trivalent nitrogen atom that is bonded only to carbon atoms, at least one of which is a member of an aromatic ring. In one form the aromatic tertiary amine can be an arylamine, such as a monoarylamine, diarylamine, triarylamine, or a polymeric arylamine. Exemplary monomeric triarylaminines are illustrated by Klupfel et al. U.S. Patent No. 3,180,730. Other suitable triarylaminines substituted with one or more vinyl radicals and/or comprising at least one active hydrogen containing group are disclosed by Brantley et al U.S. Patent Nos. 3,567,450 and 3,658,520.

A more preferred class of aromatic tertiary amines are those which include at least two aromatic tertiary amine moieties as described in U.S. Patent Nos. 4,720,432 and 5,061,569. The hole-transporting layer can be formed of a

single or a mixture of aromatic tertiary amine compounds. Illustrative of useful aromatic tertiary amines are the following:

- 1,1-Bis(4-di-p-tolylaminophenyl)cyclohexane
- 1,1-Bis(4-di-p-tolylaminophenyl)-4-phenylcyclohexane
- 5 4,4'-Bis(diphenylamino)quadriphenyl
- Bis(4-dimethylamino-2-methylphenyl)-phenylmethane
- N,N,N-Tri(p-tolyl)amine
- 4-(di-p-tolylamino)-4'-[4(di-p-tolylamino)-styryl] stilbene
- N,N,N',N'-Tetra-p-tolyl-4,4'-diaminobiphenyl
- 10 N,N,N',N'-Tetraphenyl-4,4'-diaminobiphenyl
- N,N,N',N'-tetra-1-naphthyl-4,4'-diaminobiphenyl
- N,N,N',N'-tetra-2-naphthyl-4,4'-diaminobiphenyl
- N-Phenylcarbazole
- 4,4'-Bis[N-(1-naphthyl)-N-phenylamino]biphenyl
- 15 4,4'-Bis[N-(1-naphthyl)-N-(2-naphthyl)amino]biphenyl
- 4,4''-Bis[N-(1-naphthyl)-N-phenylamino]p-terphenyl
- 4,4'-Bis[N-(2-naphthyl)-N-phenylamino]biphenyl
- 4,4'-Bis[N-(3-acenaphthenyl)-N-phenylamino]biphenyl
- 1,5-Bis[N-(1-naphthyl)-N-phenylamino]naphthalene
- 20 4,4'-Bis[N-(9-anthryl)-N-phenylamino]biphenyl
- 4,4''-Bis[N-(1-anthryl)-N-phenylamino]-p-terphenyl
- 4,4'-Bis[N-(2-phenanthryl)-N-phenylamino]biphenyl
- 4,4'-Bis[N-(8-fluoranthenyl)-N-phenylamino]biphenyl
- 4,4'-Bis[N-(2-pyrenyl)-N-phenylamino]biphenyl
- 25 4,4'-Bis[N-(2-naphthacenyl)-N-phenylamino]biphenyl
- 4,4'-Bis[N-(2-perylenyl)-N-phenylamino]biphenyl
- 4,4'-Bis[N-(1-coronenyl)-N-phenylamino]biphenyl
- 2,6-Bis(di-p-tolylamino)naphthalene
- 2,6-Bis[di-(1-naphthyl)amino]naphthalene
- 30 2,6-Bis[N-(1-naphthyl)-N-(2-naphthyl)amino]naphthalene
- N,N,N',N'-Tetra(2-naphthyl)-4,4''-diamino-p-terphenyl

4,4'-Bis {N-phenyl-N-[4-(1-naphthyl)-phenyl]amino} biphenyl

4,4'-Bis[N-phenyl-N-(2-pyrenyl)amino]biphenyl

2,6-Bis[N,N-di(2-naphthyl)amine]fluorene

1,5-Bis[N-(1-naphthyl)-N-phenylamino]naphthalene

5 4,4',4''-tris[(3-methylphenyl)phenylamino] triphenylamine

Another class of useful hole-transporting materials includes polycyclic aromatic compounds as described in EP 1 009 041. Tertiary aromatic amines with more than two amine groups can be used including oligomeric materials. In addition, polymeric hole-transporting materials can be used such as
 10 poly(N-vinylcarbazole) (PVK), polythiophenes, polypyrrole, polyaniline, and copolymers such as poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) also called PEDOT/PSS.

Light-Emitting Layer (LEL)

As more fully described in U.S. Patent Nos. 4,769,292 and
 15 5,935,721, light-emitting layer (LEL) 109 of the organic EL element includes a luminescent or fluorescent material where electroluminescence is produced as a result of electron-hole pair recombination in this region. The light-emitting layer can be comprised of a single material, but more commonly consists of a host material doped with a guest compound or compounds where light emission comes
 20 primarily from the dopant and can be of any color. The host materials in the light-emitting layer can be an electron-transporting material, as defined below, a hole-transporting material, as defined above, or another material or combination of materials that support hole-electron recombination. The dopant is usually chosen from highly fluorescent dyes, but phosphorescent compounds, e.g., transition
 25 metal complexes as described in WO 98/55561, WO 00/18851, WO 00/57676, and WO 00/70655 are also useful. Dopants are typically coated as 0.01 to 10% by weight into the host material. Polymeric materials such as polyfluorenes and polyvinylarylenes (e.g., poly(p-phenylenevinylene), PPV) can also be used as the host material. In this case, small molecule dopants can be molecularly dispersed
 30 into the polymeric host, or the dopant can be added by copolymerizing a minor constituent into the host polymer.

An important relationship for choosing a dye as a dopant is a comparison of the bandgap potential which is defined as the energy difference between the highest occupied molecular orbital and the lowest unoccupied molecular orbital of the molecule. For efficient energy transfer from the host to the dopant molecule, a necessary condition is that the band gap of the dopant is smaller than that of the host material. For phosphorescent emitters it is also important that the triplet energy level of the host be high enough to enable energy transfer from host to dopant.

Host and emitting molecules known to be of use include, but are not limited to, those disclosed in U.S. Patent Nos. 4,768,292; 5,141,671; 5,150,006; 5,151,629; 5,405,709; 5,484,922; 5,593,788; 5,645,948; 5,683,823; 5,755,999; 5,928,802; 5,935,720; 5,935,721; and 6,020,078.

Metal complexes of 8-hydroxyquinoline (oxine) and similar derivatives constitute one class of useful host compounds capable of supporting electroluminescence. Illustrative of useful chelated oxinoid compounds are the following:

CO-1: Aluminum trisoxine [alias, tris(8-quinolinolato)aluminum(III)]

CO-2: Magnesium bisoxine [alias, bis(8-quinolinolato)magnesium(II)]

CO-3: Bis[benzo{f}-8-quinolinolato]zinc (II)

CO-4: Bis(2-methyl-8-quinolinolato)aluminum(III)- μ -oxo-bis(2-methyl-8-quinolinolato)aluminum(III)

CO-5: Indium trisoxine [alias, tris(8-quinolinolato)indium]

CO-6: Aluminum tris(5-methyloxine)[alias, tris(5-methyl-8-quinolinolato) aluminum(III)]

CO-7: Lithium oxine [alias, (8-quinolinolato)lithium(I)]

CO-8: Gallium oxine [alias, tris(8-quinolinolato) gallium(III)]

CO-9: Zirconium oxine [alias, tetra(8-quinolinolato)zirconium(IV)]

Other classes of useful host materials include, but are not limited to: derivatives of anthracene, such as 9,10-di-(2-naphthyl) anthracene and derivatives thereof as described in U.S. Patent No. 5,935,721, distyrylarylene derivatives as described in U.S. Patent No. 5,121,029, and benzazole derivatives, for example, 2, 2', 2''-(1,3,5-phenylene)tris[1-phenyl-1H-benzimidazole]. Carbazole derivatives are particularly useful hosts for phosphorescent emitters.

Useful fluorescent dopants include, but are not limited to, derivatives of anthracene, tetracene, xanthene, perylene, rubrene, coumarin, rhodamine, quinacridone, dicyanomethylenepyran compounds, thiopyran compounds, polymethine compounds, pyrilium and thiapyrilium compounds, fluorene derivatives, periflanthene derivatives, indenoperylene derivatives, bis(azinyl)amine boron compounds, bis(azinyl) methane compounds, and carbostyryl compounds.

Electron-Transporting Layer (ETL)

Preferred thin film-forming materials for use in forming the electron-transporting layer 111 of the organic EL elements of this invention are metal chelated oxinoid compounds, including chelates of oxine itself (also commonly referred to as 8-quinolinol or 8-hydroxyquinoline). Such compounds help to inject and transport electrons, exhibit high levels of performance, and are readily fabricated in the form of thin films. Exemplary oxinoid compounds were listed above.

Other electron-transporting materials include various butadiene derivatives as disclosed in U.S. Patent No. 4,356,429 and various heterocyclic optical brighteners as described in U.S. Patent No. 4,539,507. Benzazoles and triazines are also useful electron-transporting materials.

Cathode

As light emission is viewed through anode 103 and substrate 20, the cathode 113 can include nearly any conductive material. Desirable materials have good film-forming properties to ensure good contact with the underlying organic layer, promote electron injection at low voltage, and have good stability. Useful cathode materials often contain a low work function metal (<4.0 eV) or metal alloy. One preferred cathode material includes a Mg:Ag alloy wherein the

percentage of silver is in the range of 1 to 20%, as described in U.S. Patent No. 4,885,221. Another suitable class of cathode materials includes bilayers comprising a thin electron-injection layer (EIL) in contact with the organic layer (e.g., ETL) which is capped with a thicker layer of a conductive metal. Here, the EIL preferably includes a low work function metal or metal salt, and if so, the thicker capping layer does not need to have a low work function. One such cathode includes a thin layer of LiF followed by a thicker layer of Al as described in U.S. Patent No. 5,677,572. Other useful cathode material sets include, but are not limited to, those disclosed in U.S. Patent Nos. 5,059,861, 5,059,862, and 6,140,763.

Cathode materials are typically deposited by evaporation, sputtering, or chemical vapor deposition. When needed, patterning can be achieved through many well known methods including, but not limited to, through-mask deposition, integral shadow masking, for example, as described in U.S. Patent No. 5,276,380 and EP 0 732 868, laser ablation, and selective chemical vapor deposition.

Other Common Organic Layers and Display Architecture

In some instances, layers 109 and 111 can optionally be collapsed into a single layer that serves the function of supporting both light emission and electron transportation. It also known in the art that light-emitting dopants can be added to the hole-transporting layer, which can serve as a host. Multiple dopants can be added to one or more layers in order to create a white-emitting OLED, for example, by combining blue- and yellow-emitting materials, cyan- and red-emitting materials, or red-, green-, and blue-emitting materials. White-emitting displays are described, for example, in EP 1 187 235, U.S. Patent Application Publication 2002/0025419, EP 1 182 244, U.S. Patent No. 5,683,823, U.S. Patent No. 5,503,910, U.S. Patent No. 5,405,709, and U.S. Patent No. 5,283,182.

Additional layers such as electron- or hole-blocking layers as taught in the art can be employed in displays of this invention. Hole-blocking layers are commonly used to improve efficiency of phosphorescent emitter displays, for example, as in U.S. Patent Application Publication 2002/0015859.

This invention can be used in so-called stacked display architecture, for example, as taught in U.S. Patent No. 5,703,436 and U.S. Patent No. 6,337,492.

Deposition of Organic Layers

5 The organic materials mentioned above are suitably deposited through a vapor-phase method such as sublimation, but can be deposited from a fluid, for example, from a solvent with an optional binder to improve film formation. If the material is a polymer, solvent deposition is useful but other methods can be used, such as sputtering or thermal transfer from a donor sheet.

10 The material to be deposited by sublimation can be vaporized from a sublimator "boat" often include a tantalum material, e.g., as described in U.S. Patent No. 6,237,529, or can be first coated onto a donor sheet and then sublimed in closer proximity to the substrate. Layers with a mixture of materials can utilize separate sublimator boats, or the materials can be pre-mixed and coated from a single boat

15 or donor sheet. Patterned deposition can be achieved using shadow masks, integral shadow masks (U.S. Patent No. 5,294,870), spatially-defined thermal dye transfer from a donor sheet (U.S. Patent Nos. 5,688,551, 5,851,709 and 6,066,357) and inkjet methods (U.S. Patent No. 6,066,357).

Optical Optimization

20 OLED displays of this invention can employ various well-known optical effects in order to enhance its properties if desired. This includes optimizing layer thicknesses to yield maximum light transmission, providing dielectric mirror structures, replacing reflective electrodes with light-absorbing electrodes, providing anti-glare or anti-reflection coatings over the display,

25 providing a polarizing medium over the display, or providing colored, neutral density, or color conversion filters over the display.

PARTS LIST

| | |
|-----|-----------------------------|
| 10 | OLED device |
| 20 | substrate |
| 30 | OLED |
| 40 | protective layer |
| 50 | foil |
| 60 | chassis structure |
| 65 | cross-brace |
| 70 | desiccant layer |
| 80 | plastic sheet |
| 90 | adhesive |
| 95 | adhesive |
| 103 | anode |
| 105 | hole-injecting layer |
| 107 | hole-transporting layer |
| 109 | light-emitting layer |
| 111 | electron-transporting layer |
| 113 | cathode |
| 130 | polymer layer |
| 140 | graphite layer |
| 150 | aluminum foil |
| 250 | power source |
| 260 | electrical conductors |

CLAIMS:

1. A flat panel OLED device comprising:
 - (a) a transparent deformable substrate having first and second sides and defining a predetermined illumination region and a non-illumination
5 region;
 - (b) a moisture-sensitive OLED disposed over the first side of the transparent substrate within the illumination region and means for applying electrical signals to the OLED which causes the OLED to produce light and heat;
 - (c) a protective layer disposed over the OLED;
 - 10 (d) a flexible encapsulating foil disposed over the protective layer, but not attached thereto, and which dissipates the heat and sealingly connected to the substrate in the non-illumination region; and
 - (e) a rigid chassis structure operatively associated with the transparent deformable substrate for providing rigidity to the transparent
15 deformable substrate.
2. The flat panel OLED device of claim 1 wherein the protective layer comprises a polymeric material.
3. The flat panel OLED device of claim 1 further including a desiccant layer over the periphery of the protective layer.
- 20 4. The flat panel OLED device of claim 1 wherein the flexible encapsulating foil includes a layer of metal foil.
5. The flat panel OLED device of claim 4 wherein the flexible encapsulating foil further includes a polymer layer.
6. The flat panel OLED device of claim 5 wherein the flexible
25 encapsulating foil comprises a polymer layer, a graphite layer, and a layer of aluminum foil.
7. The flat panel OLED device of claim 1 wherein the rigid chassis structure is an open frame structure.
8. The flat panel OLED device of claim 7 wherein the rigid
30 chassis structure comprises an aluminum cast structure.

9. The flat panel OLED device of claim 7 wherein the rigid chassis structure comprises a tubular weldment structure.

10. The flat panel OLED device of claim 7 wherein the rigid chassis structure comprises a stamped sheet metal structure.

5 11. The flat panel OLED device of claim 1 further including:
(f) a transparent optically functional plastic sheet sealingly attached to the second side of the substrate.

12. The flat panel OLED device of claim 1 wherein the OLED device is a bottom-emitting device.

10 13. A flat panel OLED display comprising:
(a) a transparent deformable substrate having first and second sides and defining a predetermined display region and a non-display region;
(b) an array of moisture-sensitive, addressable OLED pixels disposed over the first side of the transparent substrate within the display region
15 and means for applying electrical signals to the display pixels to produce light and heat;

(c) a protective layer disposed over the array of OLED pixels;
(d) a flexible encapsulating foil disposed over the protective layer, but not attached thereto, and which dissipates the heat and sealingly
20 connected to the substrate in the non-display region; and

(e) a rigid chassis structure connected to the substrate in the non-display region for providing rigidity to the transparent deformable substrate, and the rigid chassis structure being spaced from the foil in the display region.

25 14. The flat panel OLED display of claim 13 wherein the protective layer comprises a polymeric material.

15. The flat panel OLED display of claim 13 further including a desiccant layer over the periphery of the protective layer.

16. The flat panel OLED display of claim 13 wherein the flexible encapsulating foil includes a layer of metal foil.

30 17. The flat panel OLED display of claim 16 wherein the flexible encapsulating foil further includes a polymer layer.

18. The flat panel OLED display of claim 17 wherein the flexible encapsulating foil comprises a polymer layer, a graphite layer, and a layer of aluminum foil.

5 19. The flat panel OLED display of claim 13 wherein the rigid chassis structure is an open frame structure.

20. The flat panel OLED display of claim 19 wherein the rigid chassis structure comprises an aluminum cast structure.

21. The flat panel OLED display of claim 19 wherein the rigid chassis structure comprises a tubular weldment structure.

10 22. The flat panel OLED display of claim 19 wherein the rigid chassis structure comprises a stamped sheet metal structure.

23. The flat panel OLED display of claim 13 further including:
(f) a transparent optically functional plastic sheet sealingly attached to the second side of the substrate.

15 24. The flat panel OLED display of claim 13 wherein the OLED device is a bottom-emitting display.

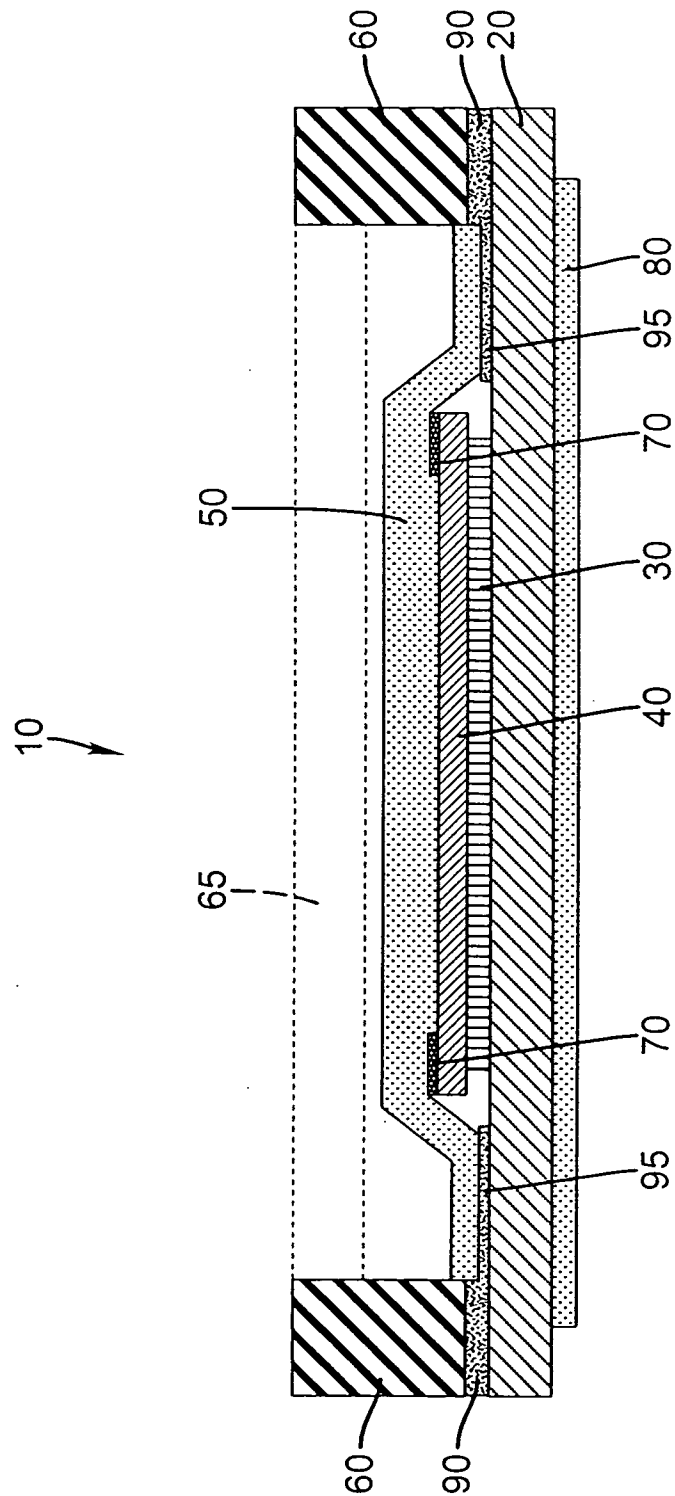
$\frac{1}{4}$ 

FIG. 1

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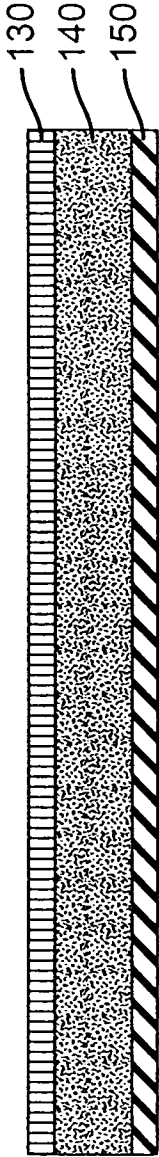


FIG. 2

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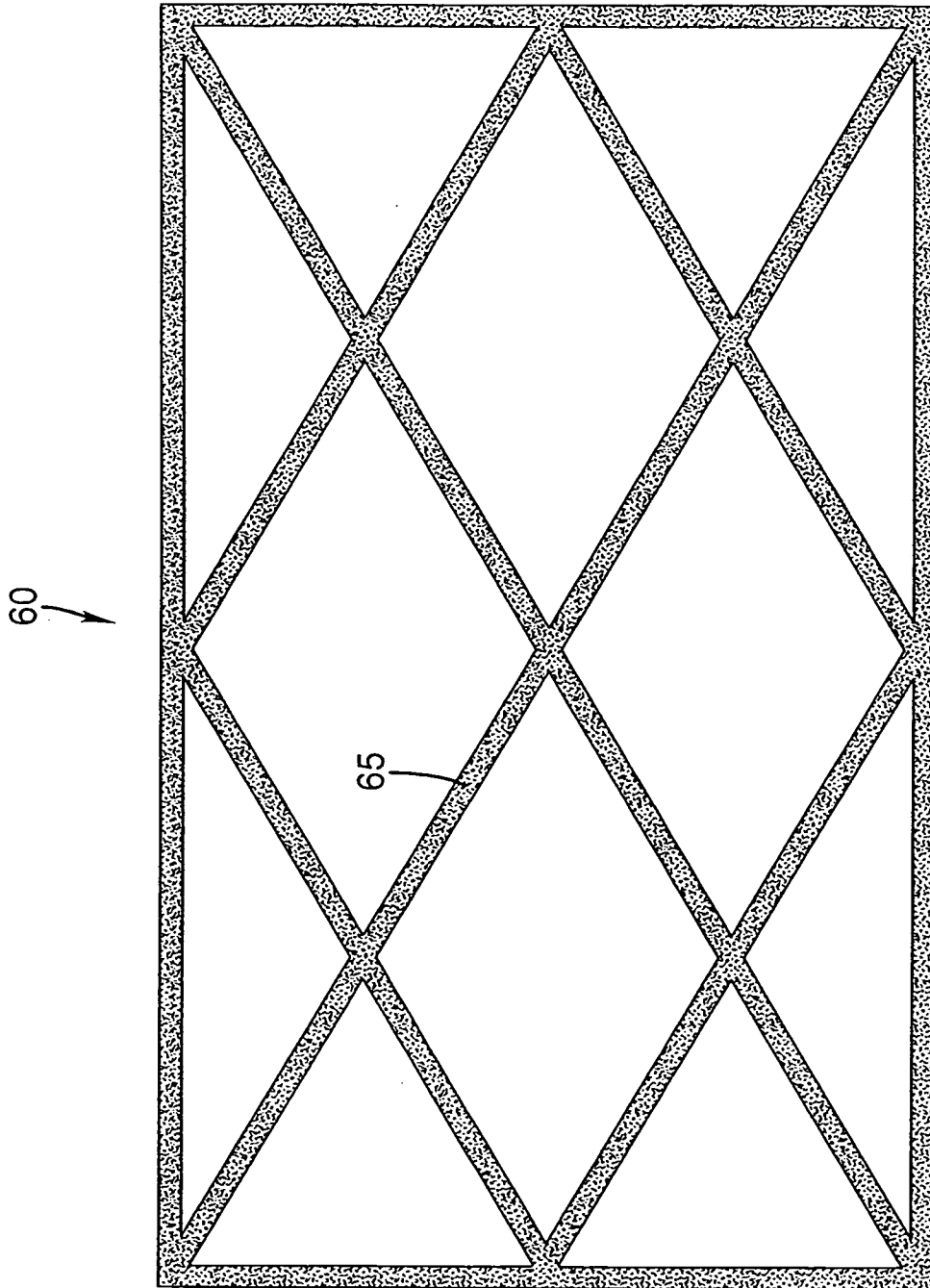


FIG. 3

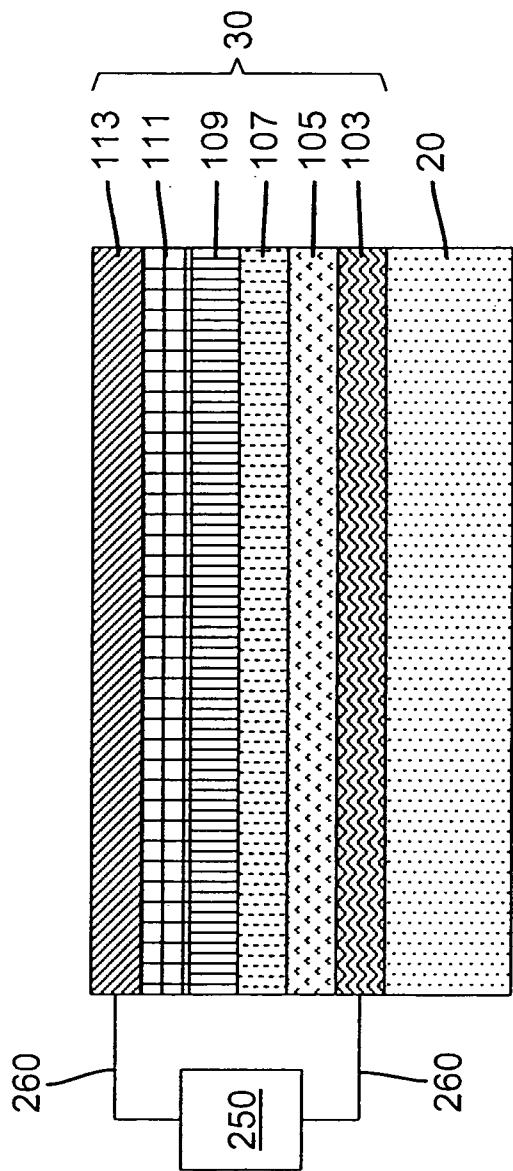


FIG. 4