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(54) **ELECTROLUMINESCENT DEVICES FABRICATED WITH ENCAPSULATED LIGHT EMITTING POLYMER PARTICLES**

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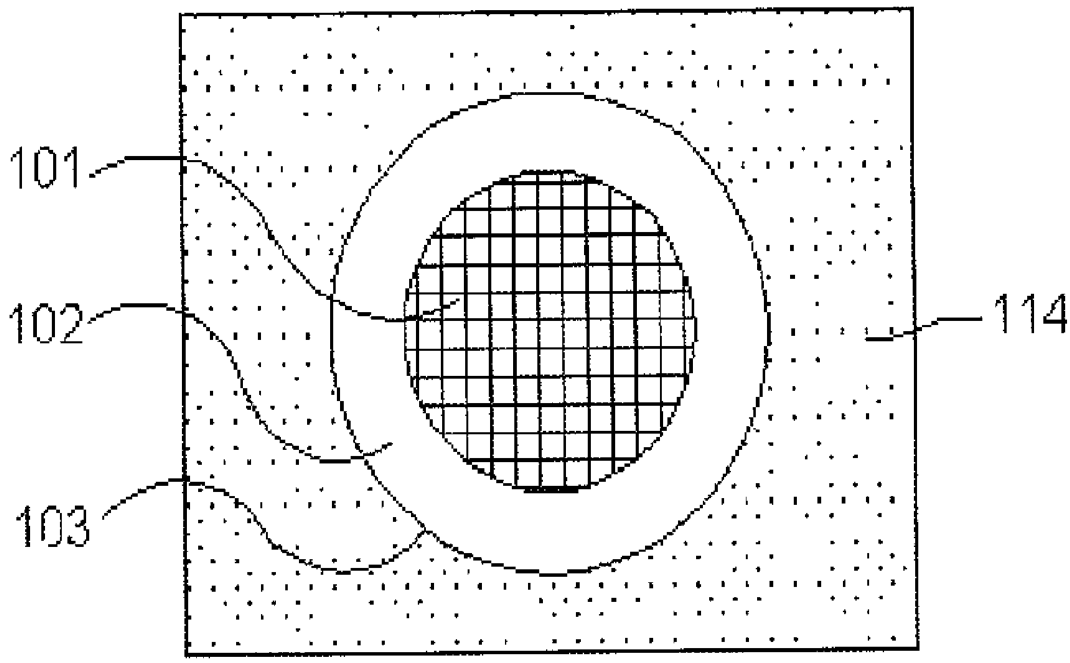
(52) **U.S. Cl.** **445/24**

(57) **ABSTRACT**

The present system provides electroluminescent devices including electroluminescent panels, and more specifically, electroluminescent devices fabricated from materials including light emitting polymers and particles comprising light emitting polymers that have been encapsulated with conductive polymers and/or insulative polymers.



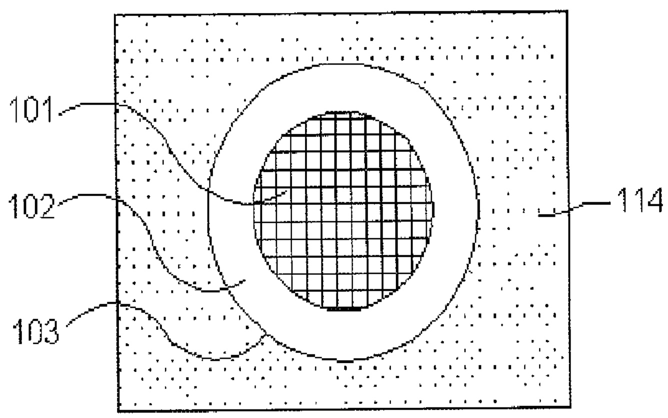


FIG. 1A

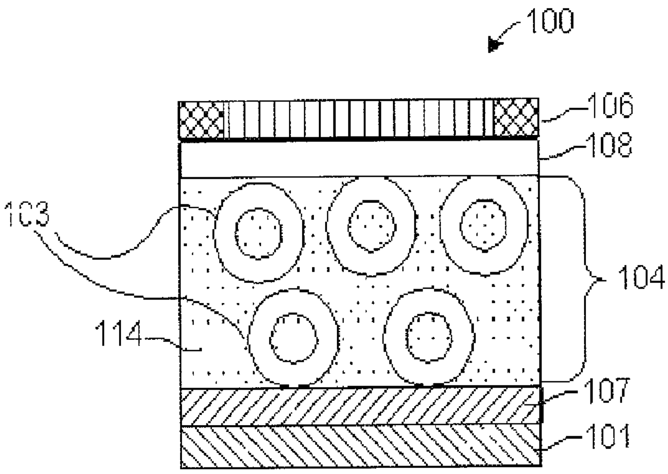


FIG. 1B

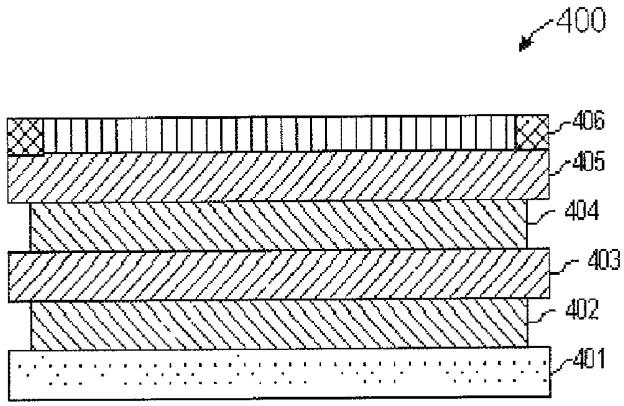


FIG. 4

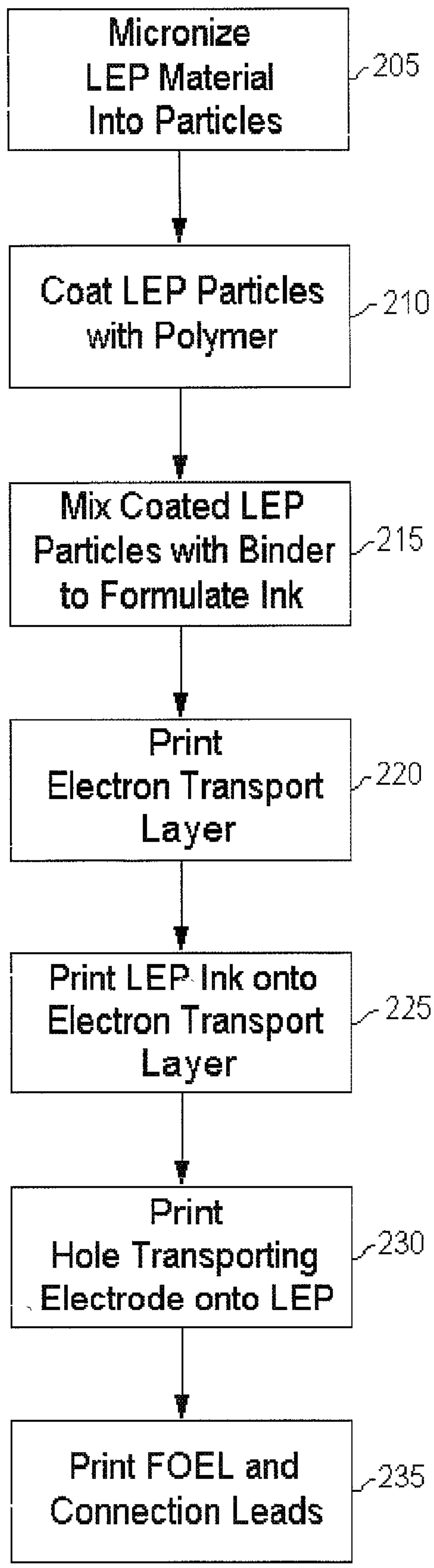

Micronize LEP Material Into Particles
205
Coat LEP Particles with Polymer
210
Mix Coated LEP Particles with Binder to Formulate Ink
215
Print Electron Transport Layer
220
Print LEP Ink onto Electron Transport Layer
225
Print Hole Transporting Electrode onto LEP
230
Print FOEL and Connection Leads
235

FIG. 2

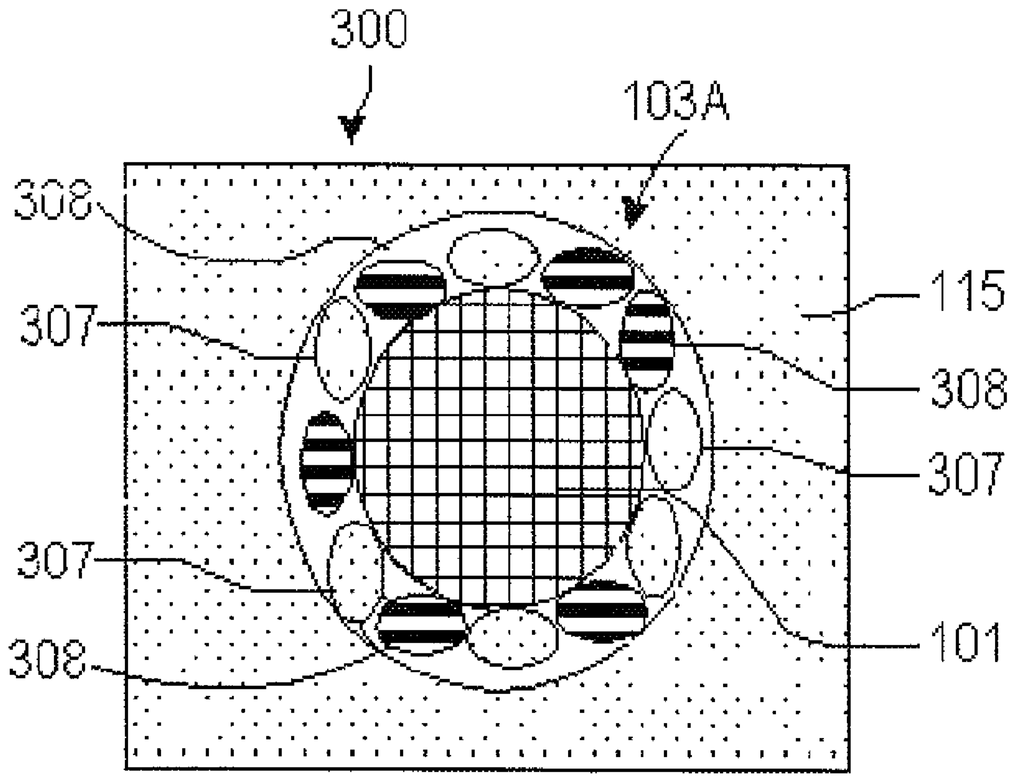


FIG. 3

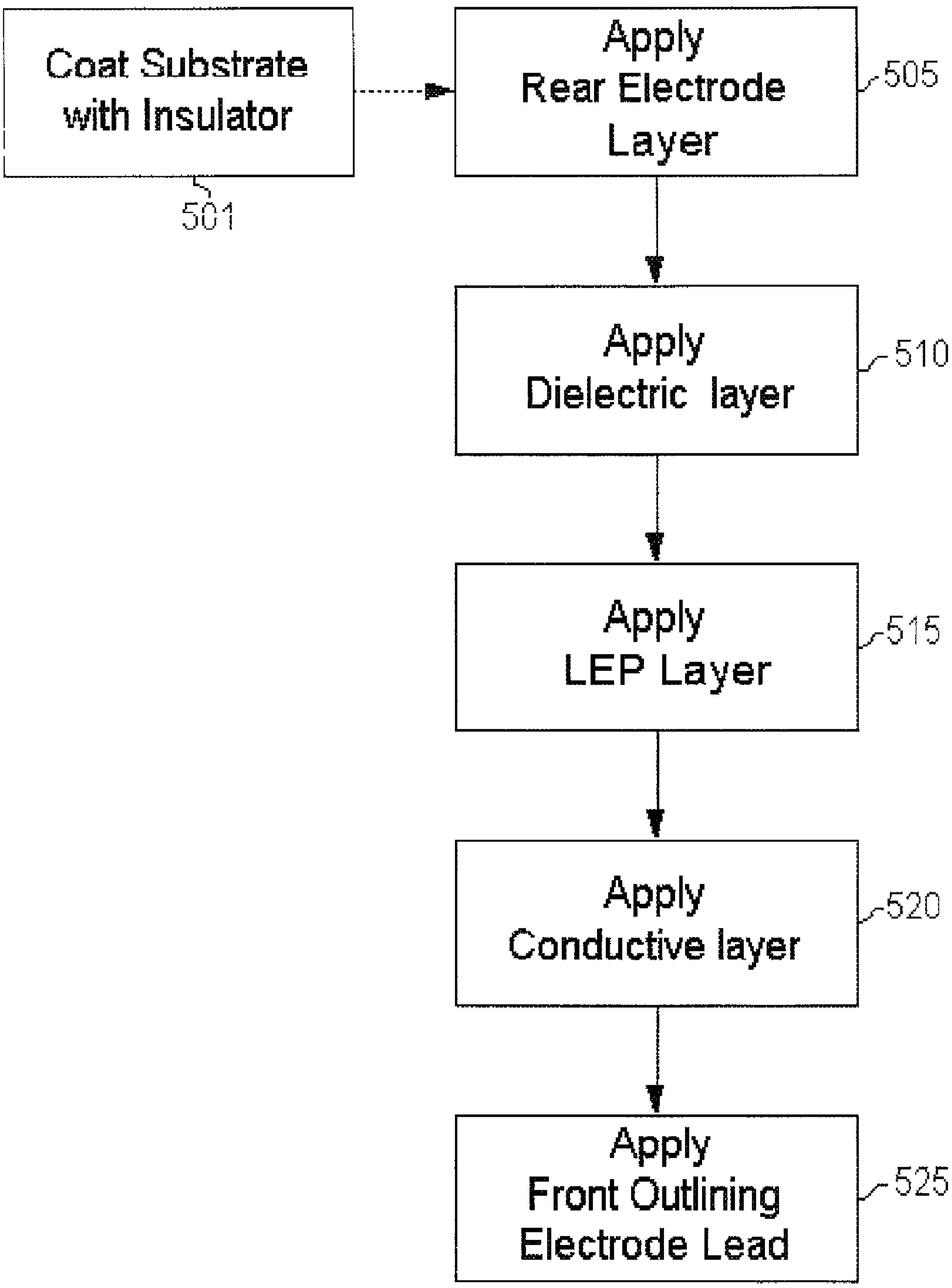

Coat Substrate with Insulator
501
Apply Rear Electrode Layer
505
Apply Dielectric layer
510
Apply LEP Layer
515
Apply Conductive layer
520
Apply Front Outlining Electrode Lead
525

FIG. 5

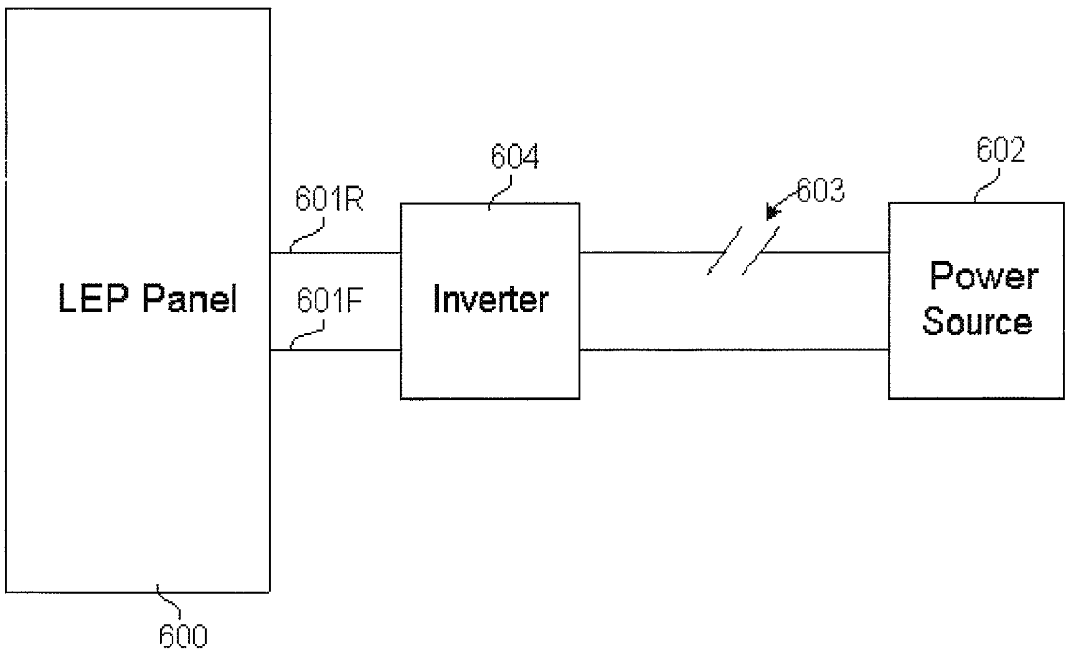


FIG. 6

ELECTROLUMINESCENT DEVICES FABRICATED WITH ENCAPSULATED LIGHT EMITTING POLYMER PARTICLES

RELATED APPLICATION

[0001] This application is a nonprovisional to U.S. application Ser. No. 60/287,321, filed Apr. 30, 2001, entitled "ELECTROLUMINSCENT DEVICE FABRICATED WITH ENCAPSULATED LIGHT EMITTING POLYMER PARTICLES" and U.S. application Ser. No. 60/287,612, filed Apr. 30, 2001, entitled "ELECTROLUMINSCENT DEVICE FABRICATED WITH ENCAPSULATED LIGHT EMITTING POLYMER PARTICLES", which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

TECHNICAL FIELD

[0002] The present system relates generally to electroluminescent devices including electroluminescent panels, and more specifically, to electroluminescent devices fabricated from materials including light emitting polymers and particles comprising light emitting polymers that have been encapsulated with conductive polymers and/or insulative polymers.

[0003] Problem:

[0004] The short lifetime of organic light emitting polymers (LEPs) is presently a major impediment to their use in commercial environments. Organic LEPs are unstable when exposed to air and humidity. In addition to oxygen, other contaminants present in air, such as ozone and NH_3, also adversely affect the useful lifetime of LEPs.

[0005] Heretofore, lamps fabricated from LEPs have been entirely encapsulated, or have had exposed surfaces coated with protective layers to achieve stability. This large-scale encapsulation/coating process is costly, and requires the use of relatively expensive transparent material.

[0006] In addition, the phosphors used in previous EL devices require relatively high voltage, typically in the range of about 60 to about 300 V AC. What is need is an electroluminescent device that requires minimal operating voltage and that exhibits long term stability in a environment containing various contaminants, such as outdoors or in industrial facilities.

[0007] Solution

[0008] The present electroluminescent display device employs organic light emitting polymer (LEP) particles encapsulated with a conductive polymer or thin, insulative polymer to provide LEP stability. The encapsulated particles are formulated into an ink system that can be printed to form a light emitting device.

[0009] Devices fabricated from light emitting polymers provide a number of advantages over phosphor electroluminescent devices including higher possible luminosity and low voltage/low current requirements resulting in low power consumption. These electrical characteristics are compatible with low voltage batteries, and allow long life with 9 volt or 1.5 volt "AA" batteries. This low power requirement makes solar powered LEP devices feasible for remote and mobile applications.

[0010] In addition, the electroluminescent LEP display device of the present invention is highly resistant to thermal shock and cycling, making it particularly suitable for use outdoors where ambient temperatures often fluctuate by large amounts.

[0011] Furthermore, in contrast to existing electroluminescent panels, such characteristics are achieved by the present invention without encapsulating the panel in an expensive material that in turn increases the cost of the panel and limits the freedom of design. The encapsulation of the LEP particles that are used to provide electroluminescence of the present invention provide protection from environmental contaminants, thus prolonging the life span of the panels.

[0012] Because of the inherent ability of the present device to function advantageously in weather extremes and also to operate for long periods of time on low voltage batteries, displays fabricated in accordance with the present invention are particularly suited to applications such as bicycle or motorcycle helmets as well as being affixed to various types of vehicles to improve their visibility and the safety of the rider or occupants. Such an illumination system also provides a mechanism for conveying an easily visible message in the form of a design logo or written information, which can be easily used on helmets and vehicles to promote brand awareness.

[0013] Panels fabricated in accordance with the present invention may be used in practically any application, indoors or outdoors, where incandescent, fluorescent, or halogen lighting is presently used.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] **FIG. 1A** is a diagram of a light emitting polymer particle encapsulated in accordance with one embodiment of present invention;

[0015] **FIG. 1B** is a diagram of a light emitting polymer electroluminescent device in accordance with one embodiment of present invention;

[0016] **FIG. 2** is a flowchart illustrating an exemplary method for fabricating an electroluminescent device in accordance with the embodiment of **FIG. 1B**;

[0017] **FIG. 3** illustrates an exemplary method for fabricating an LEP ink matrix illumination layer used in the present electroluminescent device;

[0018] **FIG. 4** is a block diagram of a light emitting polymer electroluminescent device in accordance with an alternative embodiment of present invention;

[0019] **FIG. 5** is a flowchart illustrating an exemplary method for fabricating an electroluminescent device in accordance with the embodiment of **FIG. 4**; and

[0020] **FIG. 6** illustrates an exemplary electroluminescent panel fabricated using light emitting polymers in accordance with the present method.

DETAILED DESCRIPTION

[0021] U.S. patent application Ser. No. 09/815,078, filed Mar. 22, 2001, for an "Electroluminescent Multiple Segment Display Device", discloses a system for fabricating an electroluminescent display device from materials including light emitting polymers (LEPs), the disclosure of which is herein incorporated by reference. The present electroluminescent device may include functional layers which comprise compounds that are organic or inorganic, or combinations thereof. Such a device is termed an organic/inorganic hybrid. The present electroluminescent device further includes an illumination layer comprising light emitting polymers (LEP) or LEP particles which have been encapsulated with a conductive polymer or thin, transparent or semi-transparent insulative polymer (e.g., polyvinylbutyral, Teflon, or polyethylene, etc.).

[0022] **FIG. 1A** is a diagram of a light emitting polymer particle encapsulated in accordance with one embodiment of present invention, and **FIG. 1B** is a diagram of a light emitting polymer electroluminescent device **100**, in accordance with the same embodiment. As shown in **FIGS. 1A and 1B**, LEP particles **101** are coated with a conductive polymer (e.g., an inherently conductive polymer or ICP) **102** to form an encapsulated particle **103**, which is suspended in an polymeric ink binder **114**, to form illumination layer **104**, as indicated by the dotted shading. Illumination layer **104** is sandwiched between an electron transporting layer **107** (e.g., Ag, Mg, Al, Cu, etc.) and a hole transporting layer **108** which may be organic or inorganic or a combination (e.g., PDOT, PANI, ITO, Ppy, etc.). Electron transporting layer **107** is situated on one surface of substrate **101**. A front outlining electrode lead (FOEL) **106** is situated on hole transporting electrode **108**. Power connection leads (Ag or C) are attached to electron transporting layer **107** and to hole transporting layer **108** to complete fabrication of LEP device **100**.

[0023] In operation, an AC electrical potential having a frequency of between approximately 50 Hz and 1 Khz is applied across electron transporting layer **107** and hole transporting layer **108** to cause illumination of device **100**.

LEP Particle Encapsulation Process

[0024] **FIG. 2** is a flowchart illustrating an exemplary method for fabricating an electroluminescent device in accordance with the embodiment of **FIG. 1B**. As shown in **FIG. 2**:

[0025] Step **205**: LEP particles **101** are prepared by micronizing using an air mill or grinding them to an ultimate particle size of approximately 50 microns or less. Note also that small particles are also obtainable directly in the synthetic process for preparation of the polymer. LEPs such as polypyridine, poly(p-phenylene vinylene) or poly[2-methoxy-5-(2'-ethylhexyloxy)-1,4-phenylenevinylene] may be used. Additional LEPs include poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylene-vinylene] ;poly[(2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylene-vinylene)-alt-co-(4,4'-biphenylene-vinylene)]; poly[(9,9-dioctyl-2,7-divinylenefluorenylene)-alt-co(9,10-anthracene)]; poly[(9, 9-dioctyl-2,7-divinylenefluorenylene)-alt-co-(4,4'-biphenylene)]; poly[{9,9-dioctyl-2,7-divinylene-fluorenylene}-alt-co-{2-methoxy-5-(2-ethyl-hexyloxy)-1,4-phenylene}]; poly[{9,9-dioctyl-2,7-bis(2-cyanovinylene-fluorenylene}-alt-co-{2-methoxy-5-(2-ethyl hexyloxy)-1,4-phenylene}]; poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-(1-cyanovinylenephenylene)]; poly[{9,9-dihexyl2,7-bis(1-cyanovinylene)fluorenylene}-alt-co-{2,5-bis(N, N'-diphenylamino)-1,4-phenylene}]; poly[{9-ethyl-3,6-bis(2-cyanovinylene)carbazolylene)}-alt-co-{2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylene}]; poly[(9,9-di(2-ethylhexyl)-fluorenyl-2,7-diyl)-co-(N, N'-diphenyl)-N, N'-di-(p-butyl phenyl)-1,4-diaminobenzene]; poly[2-(6-cyano-6-methylheptyloxy)-1,4-phenylene); poly]{9,9-dioctylfluorenyl-2,7-diyl}-co-{1,4-(2,5-dimethoxy)benzen poly[{9,9-dioctylfluorenyl-2,7-diyl}-co {1,4-(2,5-dimethoxy)benzene}]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(1,4-ethylenylbenzene)]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(1,4-diphenylene-vinylene-2-methoxy-5-{2-ethylhexyloxy}-benzene)]; poly[(9,9-dihexylfluorenyl-2,7-divinylenefluorenylene)]; poly[(9,9-dihexyl-2,7-(2-cyanodivinylene)fluorenylene)]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(1,4-vinylenephenylene)]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(1,4-vinylenephenylene)]; poly(9,9-dioctylfluorenyl-2,7-diyl; poly(9,9-dihexylfluorenyl-2,7-diyl); poly[9,9-di-(2-ethylhexyl)-fluorenyl-2,7-diyl]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(N,N'-diphenyl)-N,N'-di(p-butyloxyphenyl)-1,4-diaminobenzene)]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-alt-co-(N,N'-diphenyl)-N,N'-di(p-butyloxy-phenyl) 1,4-diaminobenzene)]; poly[(9, 9-dihexylfluorenyl-2,7-diyl)-co-(1,4-benzo-{2,1',3}-thiadiazole)]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-alt-co-(9,10-anthracene)]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-alt-co-(N, N'-bis{4-butylphenyl}-benzidine-N,N'-{1,4-diphenylene})]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-alt-co-(2-methoxy-5-{2-ethylhexyloxy}-1,4-phenylene)]; poly[(9, 9-dihexylfluorenyl-2,7-diyl)-co-(9,ethyl-3,6-carbazole)]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-alt-co-(9,ethyl-3,6-carbazole)]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-alt-co-(9,9'-spirobifluorene-2,7-diyl]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(2,5-p-xylene)]; poly[(9,9-dihezylfluorinl-2,7-diyl)-co-(3,5-pyridine)];poly[(9,9-dihexhglfluorenyl-2,7-diyl)-poly[(9,9-dihexylfluorenyl-2,7-diyl)-alt-co-(9,9-di-{5-pentanyl}-fluorenyl-2',7'-diyl; poly[(9,9-dihexylfluorenyl-2, 7-diyl)-co-(6,6'{2,2'-bipyridine})]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(6,6'-{2,2': 6',2"-terpyridine})]; and poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(N,N'bis{p-butylphenyl}-1,4-diamino phenylene)], all of which are commercially available from American Dye Source, Inc.

[0026] In an alternative, LEP particles may comprise OLEDs (organic light emitting devices), which includes organic and inorganic complexes, such as tris(8-hydroxyquinolato) aluminum; tetra(2-methyl-8-hydroxyquinolato) boron; lithium salt; 4,4'-bis(9-ethyl-3-carbazovinylene)-1, 1'-biphenyl; 9,10-di[(9-ethyl-3-carbazoyl)-vinylenyl)]-anthracene; 4,4'-bis(diphenylvinylenyl)-biphenyl; 1,4-bis(9-ethyl-3-carbazovinylene)-2-methoxy-5-(2-ethylhexyloxy)benzene; tris(benzoylacetone)monophenanthroline) europium (III); tris(dibenzoylmethane)mono(phenanthroline) europium (III); tris(dibenzoylmethane)mono(5-aminophenanthroline)europium (III); tris(dinapthoylmethane)monophenanthroline) europium (III); tris(diphenoylmethane)mono(phenanthroline) europium (III); tris(dibenzoylmethane)mono(4,7-diphenyl phenanthroline)europium (III); tris(dibenzoylmethane)mono(4,7-dimethyl-phenanthroline)europium (III); tris(dibenzoylmethane)mono(4,7-dihydroxy-phenanthroline)europium (Ill); tris(dibenzoylmethane)mono(4,7-dihydroxyloxy-phenanthroline)europium (III); lithium tetra(2-methyl-8-hydroxyquinolinato) boron; lithium tetra(8-hydroxyquinolinato) boron; 4,4'-bis(9-ethyl-3-carbazovinylene)-1,1'-biphenyl; bis(8-hydroxyquinolinato)zinc; bis(2-methyl-8-

hydroxyquinolinato)zinc; Iridium (III) tris(2-phenylpyridine); tris(8-hydroxyquinoline)aluminum; and tris[1-phenyl-3-methyl-4-(2,2-dimethylpropan-1-oyl)-pyrazolin-5-one]-terbium, many of which are commercially available from American Dye Source, Inc.

[0027] Light emitting polymers and OLEDs operate off low voltage and are more readily adaptable to being applied in thin layers than phosphors containing zinc sulfide, which exhibit graininess when applied as a thin coating.

[0028] Step **210**: LEP particles **101** are then coated with a conductive polymer **102** or, alternatively, a thin, insulative polymer using a fluidized bed coater. In this process, the particles are fluidized in an air or nitrogen stream and material **102** spray coated onto the particles to form encapsulated particles **103**.

[0029] Step **215**: A Printing ink **104** is then formulated by mixing the LEP particles and binder polymers (e.g. poly(methylmethacrylate) or poly(butylmethacrylate) in a suitable solvent. Other suitable binder polymers may be any suitable thermoplastic, including poly(vinylbutyral), poly(vinylalcohol), poly (vinylchloride), polycarbonate, polystyrene, poly(vinylidene chloride), poly(vinylidene fluoride), poly(acrylonitrile), poly(oxyethylene), cellulose esters, cellulose ethers, nylon 6,6, nylon 12, nylon 6,12, poly(ethylene oxide), poly(ethylene-co-vinylacetate), poly(vinylcarbazole), poly(caprolactone), polysulfone, poly(vinylpyrrolidone), poly(4-vinylphenol), poly(methyloctadecylsiloxane), and the like. Other binder systems that may be employed include systems employing thermosetting resins, for example, systems with urethane and epoxies, as well as UV-curable binder systems.

Functional Stack Printing Process

[0030] In an exemplary embodiment, a functional electroluminescent device **100** is fabricated as a plurality of layers, called a 'stack', in accordance with the following steps:

[0031] Step **220**: Print rear electrode (REL) (electron transport layer) **107** onto a suitable substrate in a desired pattern.

[0032] Step **225**: Print LEP ink layer **104** onto the rear electrode patterns **107**.

[0033] Step **230**: Print transparent hole transporting electrode **108** onto LEP layer **104**.

[0034] Step **235**. Print front outlining electrode lead (FOEL) **106** onto hole transporting electrode **108**. Print appropriate connection leads (Ag, C, or any suitable conductor) to rear electrode **107** and FOEL **106**.

[0035] In the present embodiment, the rear electrode (electron transport layer) and transparent electrode (hole transport layer) are fabricated using conductive polymers to provide a totally polymeric system without metals or metallic compounds. It should be noted that although, in the embodiment described above, each of the layers is applied in steps **220** through **235** is applied by a printing process, any of these layers may be applied by any suitable method for depositing the layer material onto the corresponding stack element.

[0036] **FIG. 3** shows an LEP ink matrix **300** formed by partially coating LEP particles **101** (only one particle is shown) with both hole transporting and electron transporting materials. One method of forming such a coating is to use a fluidized bed (as described above) with a first application of hole transporting material, which may be organic or inorganic or a combination (e.g., PDOT, PANI, ITO, Ppy, etc.) followed by an application of electron transporting material (e.g., Ag, Mg, Al, Cu, etc.) to particles **101**. In this embodiment, islands **108** of hole transporting material and islands **107** of electron transporting materials contact the LEP particles **101** to form coated particle **103**A. When an electrical field is applied, both electrons and holes are simultaneously injected into the LEP particles. These electrons and holes then recombine and emit light. LEP ink matrix **300** may be used as layer **104** in device **100**.

[0037] **FIG. 4** is a schematic illustration of an alternative embodiment of an electroluminescent (EL) multi-segment display device **400** comprising a substrate **401**, a rear electrode layer **402**, a dielectric layer **403**, an illumination layer **404**, an electrically conductive layer **405**, and a front outlining electrode lead ('front electrode') **406**. Substrate **401** may comprise either metal or an electrically non-conducting material. If, for example, an aluminum substrate is used, then it is first coated with an insulative material.

[0038] Rear electrode **402** is formed of an electrically conductive material, e.g., silver or carbon particles. Dielectric layer **403** is formed of high dielectric constant material, such as barium titanate. Illumination layer **404** is formed of LEP particles, as described above. Front electrode **406** may be formed of silver particles or other electrically conductive material.

[0039] **FIG. 5** is a flow chart showing an exemplary sequence of steps for fabricating the electroluminescent display device shown in **FIG. 1**. Fabrication of the present device **100** is best understood by viewing **FIGS. 4 and 5** in conjunction with one another. If substrate **401** is a metal or other conductor, such as aluminum, then at step **501**, an insulative coating is first applied over the substrate using a compound such as Nazdar's Plastic Plus (Nazdar Mid-America, St. Louis, Mo.). If substrate **401** is formed from a non-conductor, such as a polyester film, polycarbonate, or other plastic material, no coating is required.

[0040] At step **505**, rear electrode **402** is applied over a front surface of substrate **401**. In an exemplary embodiment, rear electrode **402** is formed of conductive particles, e.g., silver or carbon, dispersed in a polymeric or other binder to form a screen printable ink. In one embodiment, rear electrode **402** may comprise a silver particle ink such as DuPont 7145. Alternatively, rear electrode **402** may comprise a conductive organic polymer such as polyaniline, polypyrrole, and poly(3,4-ethylenedioxythiophene). In an exemplary embodiment, a carbon rear electrode **402** may have a thickness of between approximately 2×10^{4} inches and 6×10^{4} inches. It is to be noted that rear electrode layer **402**, as well as each of the layers **403-406** that are successively applied in fabricating device **100**, may be applied by any appropriate method, including an ink jet process, a stencil, flat coating, brushing, rolling, spraying, etc.

[0041] Rear electrode layer **402** may cover the entire substrate **401**, but this layer **402** typically covers only the illumination area (the area covered by LEP layer **404**, described below).

[0042] At step **510**, optional dielectric layer **403** is applied over rear electrode layer **402**. In an exemplary embodiment, dielectric layer **48** comprises a high dielectric constant inorganic material, such as barium titanate dispersed in a polymeric binder to form a screen printable ink. In one embodiment, the dielectric may be an ink such as DuPont 7153. Dielectric layer **403** may cover substrate **401** either entirely, or may alternatively cover only the illumination area. Alternatively, dielectric layer **403** may include a high dielectric constant inorganic material such as alumina oxide dispersed in a polymeric binder. The alumina oxide layer is applied over rear electrode **164** and cured by exposure to UV light. In an exemplary embodiment, dielectric layer **403** may have a thickness of between approximately 6×10^{-4} inches and 1.5×10^{-3} inches.

[**0043**] In accordance with one embodiment, dielectric layer **402** has substantially the same shape as the illumination area, but extends approximately 1/16" to 1/8" beyond the illumination area. Alternatively, dielectric layer **402** may cover substantially all of substrate **401**.

[**0044**] At step **515**, illumination layer **404** is applied over dielectric layer **210**. Illumination layer **404** is formulated in accordance with the process described above with respect to **FIGS. 1A, 1B**, and **2**. The size of the illumination area covered by LEP layer **404** may range from approximately 1 sq. inch to 100 sq. inches. In an exemplary embodiment of the present system, illumination layer **404/104** comprises light emitting polymers, and has a thickness of between approximately 8×10^{-4} inches and 1.2×10^{-3} inches.

[**0045**] At step **520**, conductive layer **405** is printed over LEP layer **404**, extending about 1/16" to 1/8" beyond LEP area **404**. The distance beyond the Illumination layer to which conductive layer **405** extends is a function of the size of the device. Accordingly, the extension of conductive layer **405** beyond Illumination area **404** may advantageously be between approximately 2 percent and 10 percent of the width of Illumination layer **404**. In an exemplary embodiment, conductive layer **405** comprises an inorganic compound such as indium tin oxide (ITO) particles in the form of a screen printable ink such as DuPont 7160. In an alternative embodiment, conductive layer is non-metallic and is translucent or transparent, and comprises an organic conductive polymer, such as polyaniline, pyrrole, or poly(3, 4-ethylenedioxythiophene). In an exemplary embodiment, an ITO conductive layer **405** may have a thickness of between approximately 2×10^{-4} inches and 5×10^{-4} inches.

[**0046**] At step **525**, a front electrode, or more specifically, a front outlining electrode layer **406**, comprising a conductive material such as silver or carbon, is applied onto the outer perimeter of conductive layer **405** to transport energy thereto. Front electrode **406** is typically 1/16" to 1/8" wide strip, approximately 2 percent to 20 percent of the width of conductive layer **405**, depending on the current drawn by device **100** and the length of the device from the controller or power source. For example, front electrode **406** may be approximately 1/8" wide for a 50" wire run from the controller.

[**0047**] Front electrode leads **510** may be screen printed onto substrate **401**, or may be fabricated as interconnect tabs **511** extending beyond the substrate to facilitate connection to a power source or controller. In one embodiment, front outlining electrode layer **406** contacts substantially the entire outer perimeter of conductive layer **405** and does not overlap rear electrode **409**. In an alternative embodiment, front electrode **406** contacts only about 25% of outer perimeter of conductive layer **405**. Front electrode may be fabricated to contact any amount of the outer perimeter of conductive layer **405** from about 25% to about 100%. Front outlining electrode **406** may, for example, comprise silver particles that form a screen printable ink such as DuPont 7145. In an alternative embodiment, front outlining electrode **406** is non-metallic and is translucent or transparent, and comprises an organic conductive polymer, such as polyaniline, polypyrrole, or poly(3,4-ethylenedioxythiophene). Fabricating front and rear electrodes **406/102** with polymers such as the aforementioned compounds would make device **100** more flexible, as well as more durable and corrosion resistant. In an exemplary embodiment, a silver front outlining electrode layer **406** may have a thickness of between approximately 8×10^{-4} inches and 1.1×10^{-3} inches.

[**0048**] **FIG. 6** provides a further illustration of a an exemplary electroluminescent LEP panel **600** fabricated using light emitting polymers in accordance with the presently disclosed embodiments. As shown in **FIG. 6**, panel **600** achieves electroluminescence by the application of an electrical current to rear and front electrode layers **107** and **106**. For EL panels that require AC power, DC power source **602** is connected to an inverter **604** with the output of inverter **604** being directed to leads **601**R and **601**F, connected to rear electrode layer **107** and front electrode layer **106**, respectively. Control switch **603** is placed between power source **602** and inverter **604** in order to allow the user of panel **600** to selectively turn the electroluminescent function to ON or OFF positions. If EL panel **600** operates with DC power, inverter **604** is not required, and leads **601**R and **601**F are connected directly to switch **606**. Control switch **603** may be a two-position ON/OFF switch, a dimmer switch, a slide switch, a switch capable of causing on and off flashing, a remote control switch, or any other control switch that may cause a desired effect. Control switch **603** may also be a manually operated switch or an automatic switch that has been preprogrammed to activate and deactivate panel **600** in response to certain conditions, such as the onset of darkness.

What is claimed is:

1. A method for fabricating an electroluminescent display device comprising:

encapsulating LEP particles with a conductive polymer;

formulating an LEP ink by mixing the encapsulated LEP particles with binder polymers;

depositing a conducting rear electrode onto a substrate in a pattern;

depositing the LEP ink onto REL patterns to form an LEP layer;

depositing a transparent hole transporting electrode onto the LEP layer;

depositing a front outlining electrode onto the hole transporting electrode; and

depositing connection leads to the rear electrode and the front outlining electrode.

2. The method of claim 1 wherein said display device is an electroluminescent panel.

3. The method of claim 1 wherein said LEP particles are selected from the group consisting of polypyridine; poly(p-phenylene vinylene); poly[2-methoxy-5-(2'-ethylhexyloxy)-1,4-phenylenevinylene]; poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylene-vinylene]; poly[(2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylene-vinylene)-alt-co-(4,4'-biphenylene-vinylene)]; poly[(9,9-dioctyl-2,7-divinylenefluorenylene)-alt-co-(9,10-anthracene)]; poly[(9,9-dioctyl-2,7-divinylenefluorenylene)-alt-co-(4,4'-biphenylene)];poly[{9,9-dioctyl-2,7-divinylene-fluorenylene}-alt-co-{2-methoxy-5-(2-ethyl-hexyloxy)-1,4phenylene-}]; poly[{9,9-dioctyl-2,7-bis(2-cyanovinylene-fluorenylene}-alt-co-{2-methoxy-5-(2-ethyl hexyloxy)-1,4-phenylene}]; poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-(1-cyanovinylenephenylene)]; poly[{9,9-dihexyl-2,7-bis(1-cyanovinylene)fluorenylene}-alt-co-{2,5-bis(N,N'-diphenylamino)-1,4-phenylene}]; poly[{9-ethyl-3,6-bis(2-cyanovinylene)carbazolylene)}-alt-co{2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylene}]; poly[(9,9-di(2-ethylhexyl)-fluorenyl-2,7-diyl)-co-(N,N'-diphenyl)-N,N'-di-(p-butyl phenyl)-1,4-diaminobenzene]; poly[2-(6-cyano-6-methylheptyloxy)-1,4-phenylene); poly[{9,9-dioctylfluorenyl-2,7-diyl}-co-{1,4-(2,5-dimethoxy)benzene}]; poly[{9,9-dioctylfluorenyl-2,7-diyl}-co-{1,4-(2,5-dimethoxy)benzene}]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(1,4-ethylenylbenzene)]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(1,4-diphenylene-vinylene-2-methoxy-5-{2-ethylhexyloxy}-benzene)]; poly[(9,9-dihexylfluorenyl-2,7-divinylenefluorenylene)]; poly[(9,9-dihexyl-2,7-(2-cyanodivinylene)-fluorenylene)]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(1,4-vinylenephenylene)]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(1,4-vinylenephenylene)]; poly(9,9-dioctylfluorenyl-2,7-diyl; poly(9,9-dihexylfluorenyl-2,7-diyl); poly[9,9-di-(2-ethylhexyl)-fluorenyl-2,7-diyl]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(N,N'-diphenyl)-N,N'-di(butyloxyphenyl) -1,4-diaminobenzene)]; poly[(9,9-dioctylfluorenyl-2,7-diyl)alt-co-(N,N'-diphenyl)-N,N'-di(p-butyloxyphenyl)-1,4-diaminobenzene)]poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(1,4-benzo-{2,1',3}-thiadiazole)]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-alt-co-(9,10-anthracene)]; poly[(9,9-dioctylfluorenyl-2,7-diyl)-alt-co-(N,N'-bis{4-butylphenyl}-benzidine- N,N'-{1,4-diphenylene})]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-alt-co-(2-methoxy-5-{2-ethylhexyloxy}-1,4-phenylene)]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(9,ethyl-3,6-carbazole)]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-alt-co-(9,ethyl-3,6-carbazole)]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-alt-co-(9,9'-spirobifluorene-2,7-diyl]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(2,5-p-xylene)]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(3,5-pyridine)]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(1,4-phenylene)]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-alt-co-(9,9-di-{5-pentanyl}-fluorenyl-2',7'-diyl; poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(6,6'{2,2'-bipyridine})]; poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(6,6'-{2,2': 6',2"-terpyridinel})]; and poly[(9,9-dihexylfluorenyl-2,7-diyl)-co-(N,N'bis {p-butylphenyl}-1,4-diamino phenylene)], and combinations thereof.

4. The method of claim 1 wherein said LEP particles are organic light emitting devices which are selected from the group consisting of tris(8-hydroxyquinolato) aluminum; tetra(2-methyl-8-hydroxyquinolato) boron; lithium salt; 4,4'-bis(9-ethyl-3-carbazovinylene)-1,1'-biphenyl; 9,10-di[(9-ethyl-3carbazoyl)-vinylenyl)]-anthracene; 4,4'-bis-(diphenylvinylenyl)-biphenyl; 1,4-bis(9-ethyl-3-carbazovinylene)-2-methoxy-5-(2-ethylhexyloxy)benzene; tris(benzoylacetone)mono(phenanthroline) europium (III); tris(dibenzoylmethane)mono(phenanthroline) europium (III); tris(dibenzoylmethane)mono(5-aminophenanthroline)europium (III); tris(dinapthoylmethane)mono(phenanthroline) europium (III); tris(biphenoylmethane)mono(phenanthroline) europium (III); tris(dibenzoylmethane)mono(4,7-diphenyl phenanthroline)europium (III); tris(dibenzoylmethane)mono(4,7-dimethyl-phenanthroline)europium (III); tris(dibenzoylmethane)mono(4,7-dihydroxy-phenanthroline)europium (III); tris(dibenzoylmethane)mono(4,7-dihydroxyloxy-phenanthroline)europium (III); lithium tetra(2-methyl-8-hydroxyquinolinato) boron; lithium tetra(8-hydroxyquinolinato) boron; 4,4'-bis(9-ethyl-3-carbazovinylene)-1,1'-biphenyl; bis(8-hydroxyquinolinato)zinc; bis(2-methyl-8-hydroxyquinolinato)zinc;Iridium (III) tris(2-phenylpyridine); tris(8-hydroxyquinoline)aluminum; and tris[1-phenyl-3-methyl-4-(2,2-dimethylpropan-1-oyl)-pyrazolin-5-one]-terbium, and combinations thereof.

5. The method of claim 1 wherein said binder polymers are selected from the group consisting of poly(methylmethacrylate), poly(butylmethacrylate), poly(vinylbutyral), poly(vinylalcohol), poly (vinylchloride), polycarbonate, polystyrene, poly(vinylidene chloride), poly(vinylidene fluoride), poly(acrylonitrile), poly(oxyethylene), cellulose esters, cellulose ethers, nylon 6,6, nylon 12, nylon 6,12, poly(ethylene oxide),poly(ethylene-co-vinylacetate), poly-(vinylcarbazole), poly(caprolactone), polysulfone, poly(vinylpyrrolidone), poly(4-vinylphenol), poly(methyloctadecylsiloxane), and combinations thereof.

6. The method of claim 1 wherein said conducting rear electrode comprises an inorganic compound.

7. The method of claim 6 wherein said inorganic compound comprises indium tin oxide.

8. The method of claim 1 wherein said conducting rear electrode comprises an organic compound.

9. The method of claim 8 wherein said organic compound is a conductive polymer selected from the group consisting of polyaniline, polypyrrole, poly(3,4-ethylenedioxythiophene), and combinations thereof.

10. The method of claim 1 wherein said conducting rear electrode is a mixture of inorganic and organic compounds.

11. The method of claim 10 wherein said compounds are selected from the group consisting of indium tin oxide, polyaniline, polypyrrole, poly(3,4-ethylenedioxythiophene), and combinations thereof.

12. The method of claim 1 wherein said hole transporting electrode is selected from the group consisting of PDOT, PANI, ITO, and Ppy, and combinations thereof.

13. The method of claim 1 wherein said front outlining electrode is selected from the group consisting of silver and carbon.

14. The method of claim 1 wherein said electroluminescent display device comprises an organic/inorganic hybrid.

15. The method of claim 1, wherein any of the depositing steps are performed by a printing process.

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专利名称(译)	用封装的发光聚合物颗粒制造的电致发光器件		
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摘要(译)

本系统提供包括电致发光面板的电致发光器件，更具体地，由包括发光聚合物和包含已用导电聚合物和/或绝缘聚合物封装的发光聚合物的颗粒的材料制成的电致发光器件。