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An agency of Industry Canada

CA 2473969 A1 2002/11/07

(21) 2 473 969

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2002/04/30
(87) Date publication PCT/PCT Publication Date: 2002/11/07
(85) Entrée phase nationale/National Entry: 2004/07/21
(86) N° demande PCT/PCT Application No.: US 2002/013547
(87) N° publication PCT/PCT Publication No.: 2002/087308
(30) Priorités/Priorities: 2001/04/30 (60/287,321) US;
2001/04/30 (60/287,612) US

(51) Cl.Int.^{7}/Int.Cl.^{7} H05B 33/10, H05B 33/14

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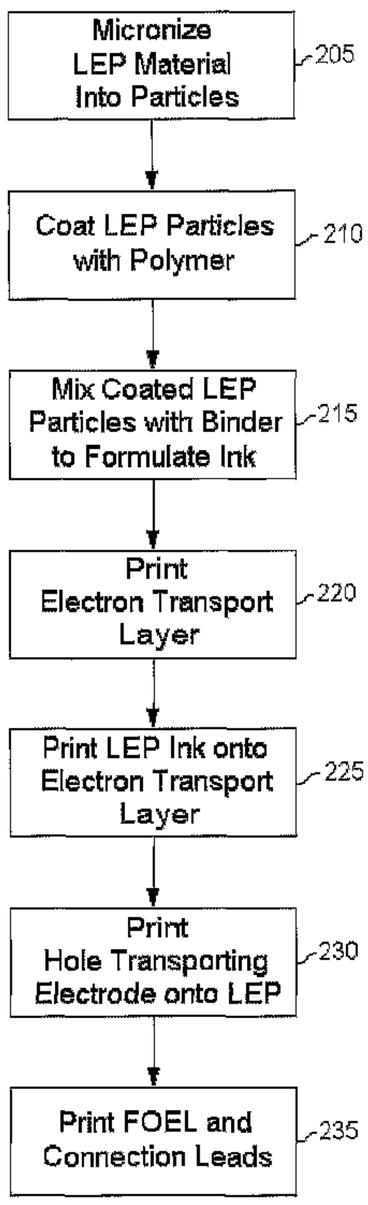
(54) Titre : DISPOSITIFS ELECTROLUMINESCENTS FABRIQUES A PARTIR DE PARTICULES POLYMERES PHOTOEMETTRICES ENCAPSULEES

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



(57) Abrégé/Abstract:
Method of making an electroluminescent device comprising providing light emitting polymer particles (205), encapsulated the particles in a conductive polymer film (210), mixing the coated particles with a binder to form an ink (215), printing the ink onto a electron transporting layer (225), printing a hole transport layer over the ink (230) and printing a front outlining electrode and appropriate connection leads (235).

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 November 2002 (07.11.2002)

PCT

(10) International Publication Number
WO 02/087308 A3

(51) International Patent Classification[7]: H05B 33/10, 33/14

(21) International Application Number: PCT/US02/13547

(22) International Filing Date: 30 April 2002 (30.04.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/287,612 30 April 2001 (30.04.2001) US
60/287,321 30 April 2001 (30.04.2001) US

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent

[Continued on next page]

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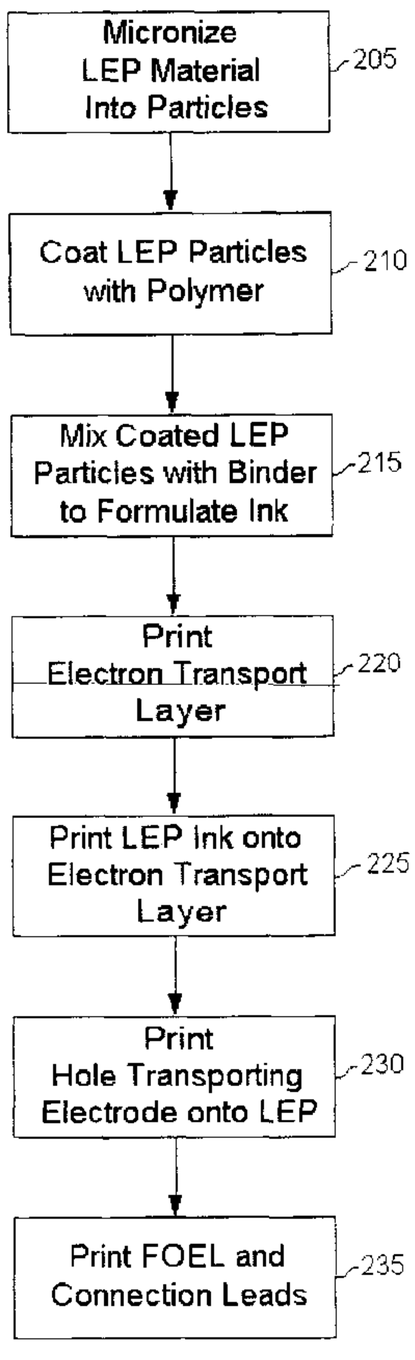

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WO 02/087308 A3

WO 02/087308 A3

(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(88) Date of publication of the international search report:
1 May 2003

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ELECTROLUMINESCENT DEVICES FABRICATED WITH ENCAPSULATED LIGHT EMITTING POLYMER PARTICLES

BACKGROUND OF THE INVENTION

Technical Field

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.

Problem:

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.

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.

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.

Solution

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.

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.

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.

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.

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.

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

Figure 1A is a diagram of a light emitting polymer particle encapsulated in accordance with one embodiment of present invention;

Figure 1B is a diagram of a light emitting polymer electroluminescent device in accordance with one embodiment of present invention;

Figure 2 is a flowchart illustrating an exemplary method for fabricating an electroluminescent device in accordance with the embodiment of Figure 1B;

Figure 3 illustrates an exemplary method for fabricating an LEP ink matrix illumination layer used in the present electroluminescent device;

Figure 4 is a block diagram of a light emitting polymer electroluminescent device in accordance with an alternative embodiment of present invention; ~~and~~

Figure 5 is a flowchart illustrating an exemplary method for fabricating an electroluminescent device in accordance with the embodiment of Figure 4; and

Figure 6 illustrates an exemplary electroluminescent panel fabricated using light emitting polymers in accordance with the present method.

DETAILED DESCRIPTION

U.S. Patent Application Serial Number 09/815,078, filed March 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.).

Figure 1A is a diagram of a light emitting polymer particle encapsulated in accordance with one embodiment of present invention, and Figure 1B is a diagram of a light emitting polymer electroluminescent device 100, in accordance with the same embodiment. As shown in Figures 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.

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

LEP Particle Encapsulation Process

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

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-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(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-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"-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.

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(benzoylacetonato)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, many of which are commercially available from American Dye Source, Inc.

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.

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.

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

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:

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

Step 225: Print LEP ink layer 104 onto the rear electrode patterns 107.

Step 230: Print transparent hole transporting electrode 108 onto LEP layer 104.

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.

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.

Figure 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 103A. 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.

Figure 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.

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.

Figure 5 is a flow chart showing an exemplary sequence of steps for fabricating the electroluminescent display device shown in Figure 1. Fabrication of the present device 100 is best understood by viewing Figures 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.

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 $2x10^{-4}$ inches and $6x10^{-4}$ 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.

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).

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 $6x10^{-4}$ inches and $1.5x10^{-3}$ inches.

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.

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 Figures 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 $8x10^{-4}$ inches and $1.2x10^{-3}$ inches.

At step 520, conductive layer 405 is printed over LEP layer 404, extending about 1/16" to1/8" 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 $2x10^{-4}$ inches and $5x10^{-4}$ inches.

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.

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 $8x10^{-4}$ inches and $1.1x10^{-3}$ inches.

Figure 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 Figure 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 601R and 601F, 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 601R and 601F 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.

CLAIMS

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)-1,4-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-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(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-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"-terpyridine})] ; 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-3-carbazoyl)-vinylenyl)]-anthracene; 4,4'-bis(diphenylvinylenyl)-biphenyl; 1,4-bis(9-ethyl-3-carbazovinylene)-2-methoxy-5-(2-ethylhexyloxy)benzene; tris(benzoylacetonato)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.

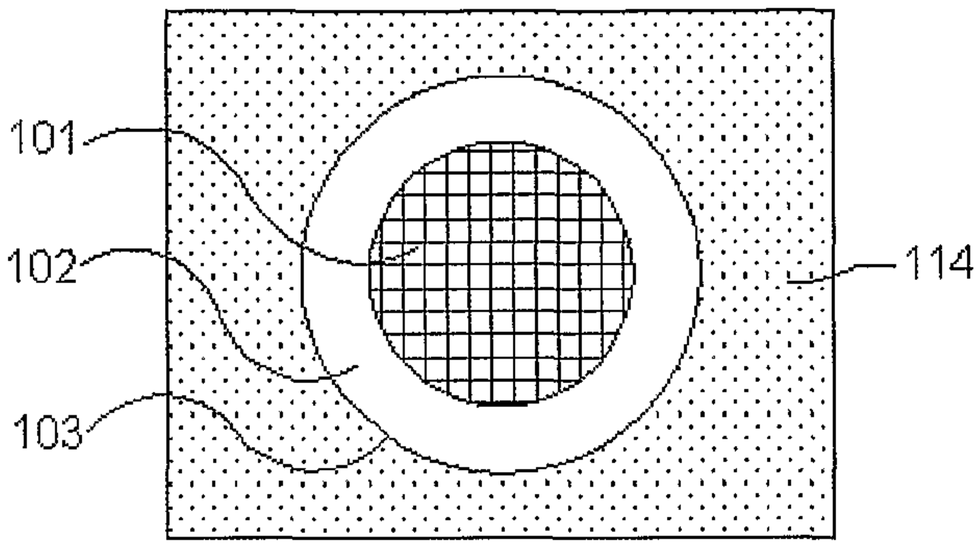


FIG. 1A

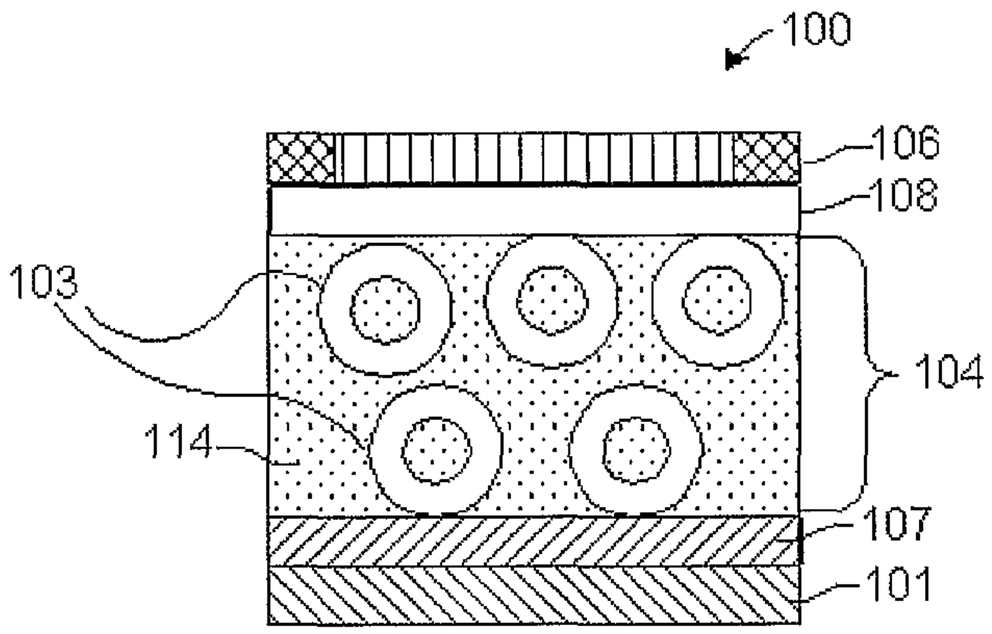


FIG. 1B

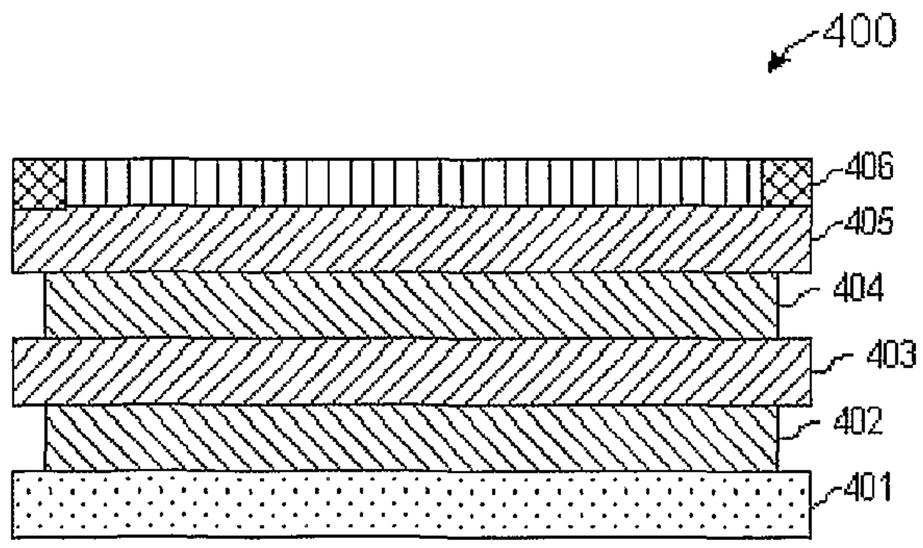


FIG. 4

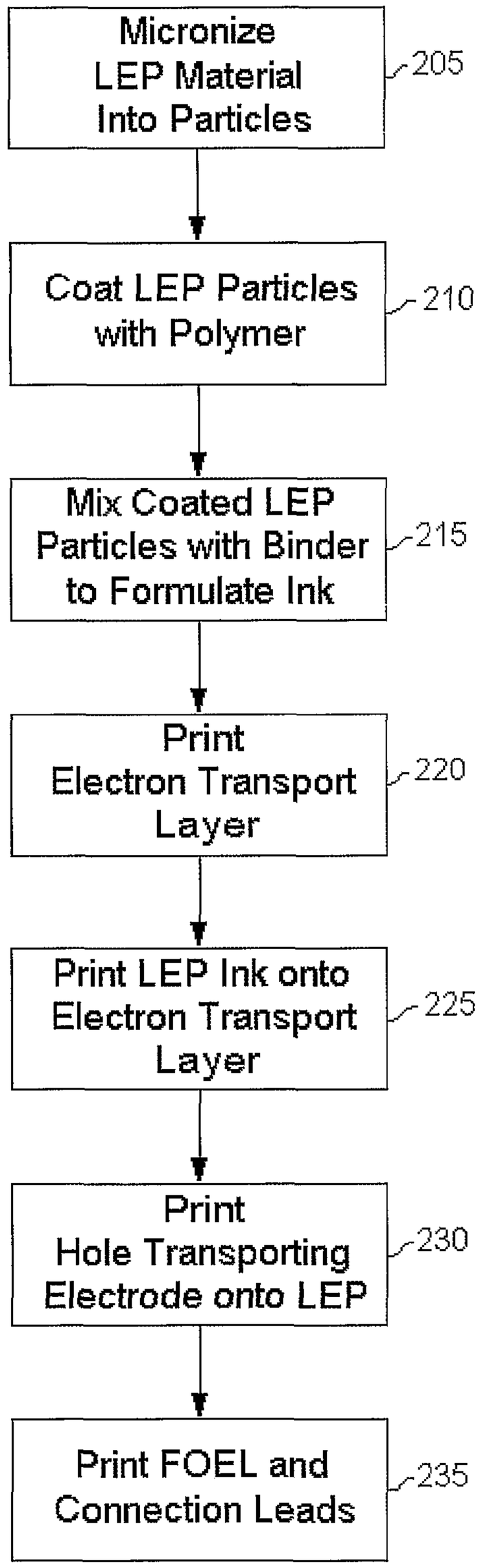

Micronize LEP Material Into Particles
205
Coat LEP Particles with Polymer
210
Mix Coated LEP Particles with Binder to Formulate Ink
215
Print Electron Transport Layer
220
Print LEP Ink onto Electron Transport Layer
225
Print Hole Transporting Electrode onto LEP
230
Print FOEL and Connection Leads
235

FIG. 2

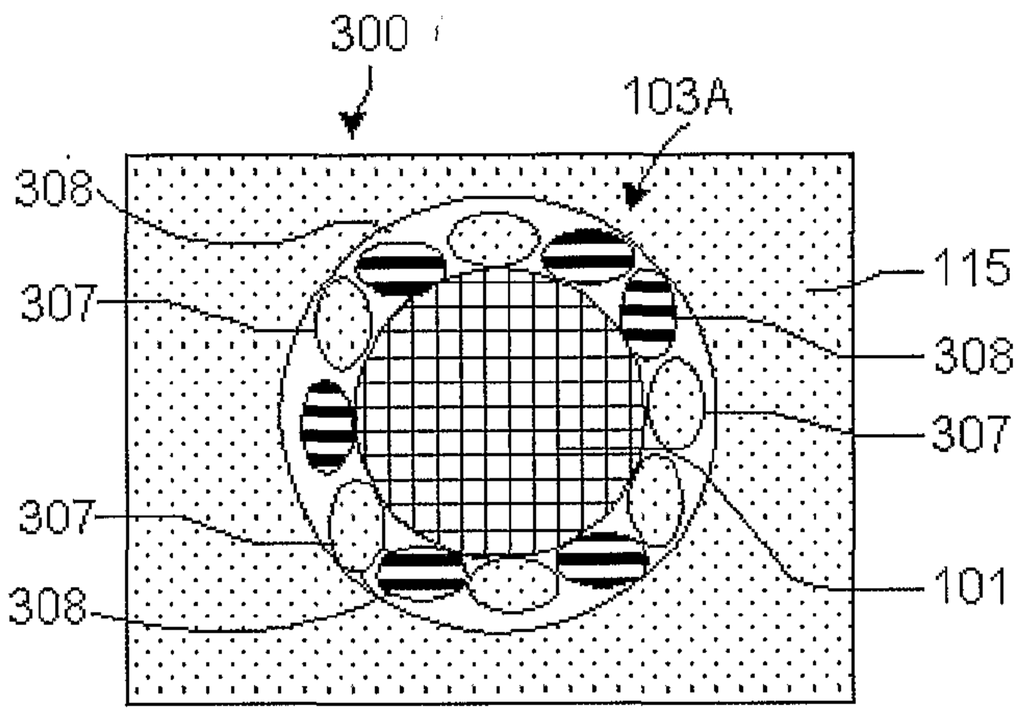


FIG. 3

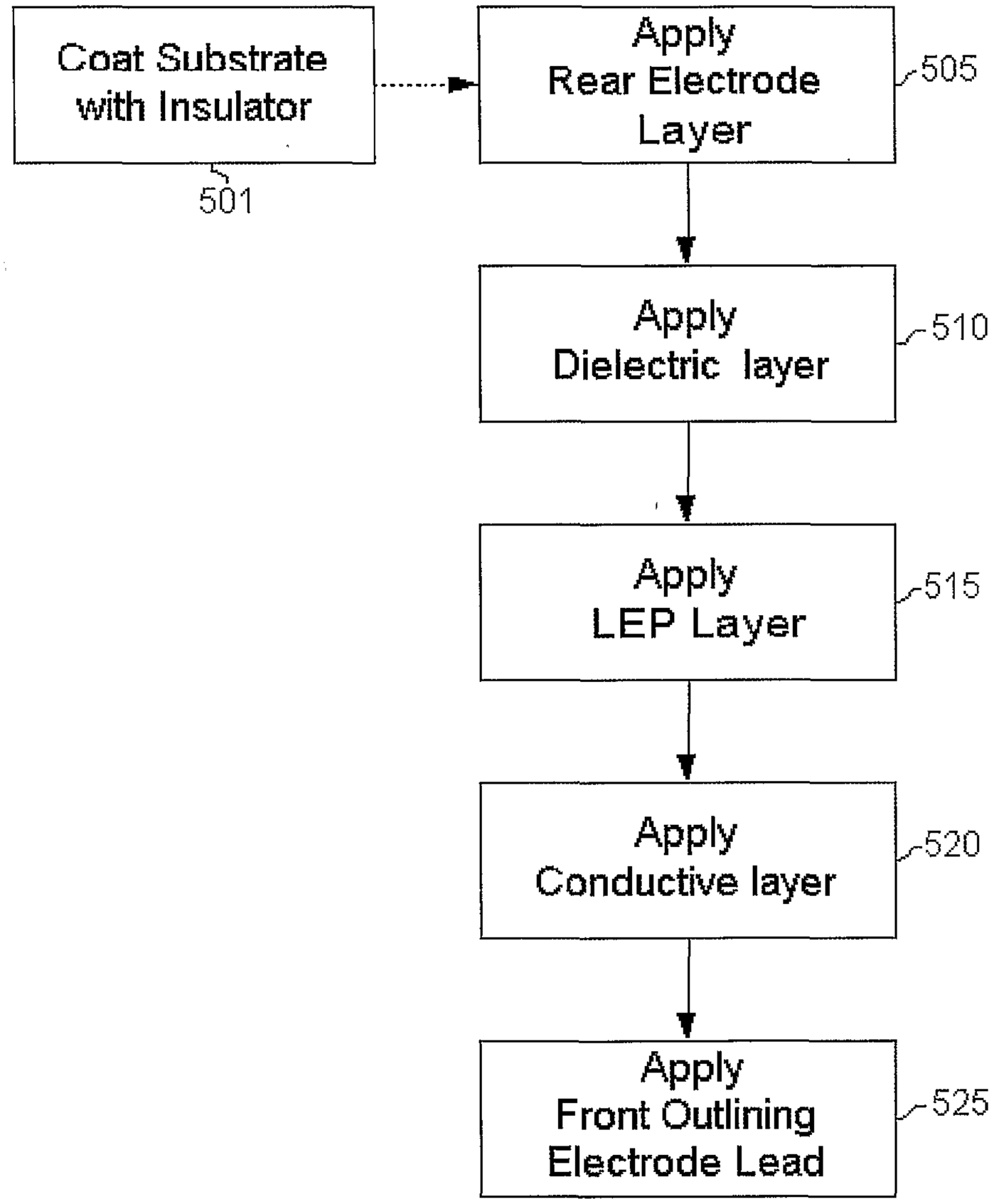

Coat Substrate with Insulator
501
Apply Rear Electrode Layer
505
Apply Dielectric layer
510
Apply LEP Layer
515
Apply Conductive layer
520
Apply Front Outlining Electrode Lead
525

FIG. 5

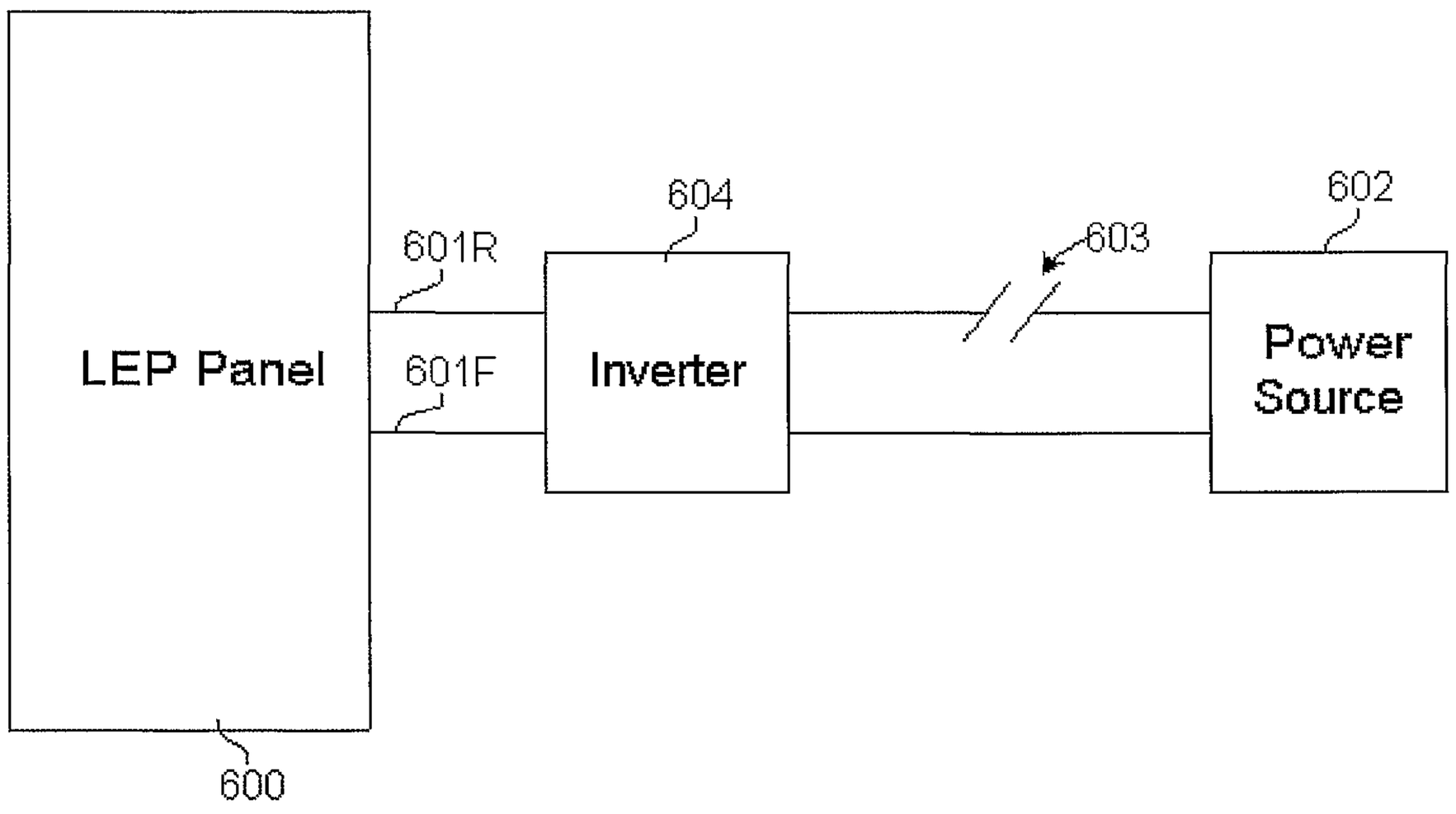
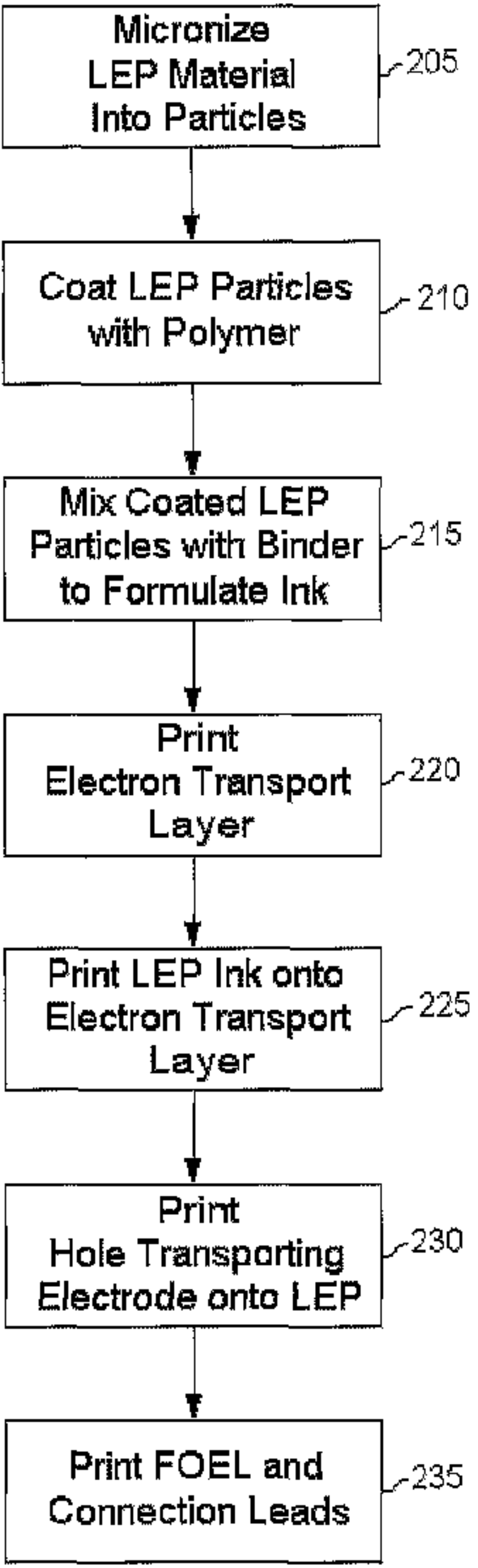


FIG. 6


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