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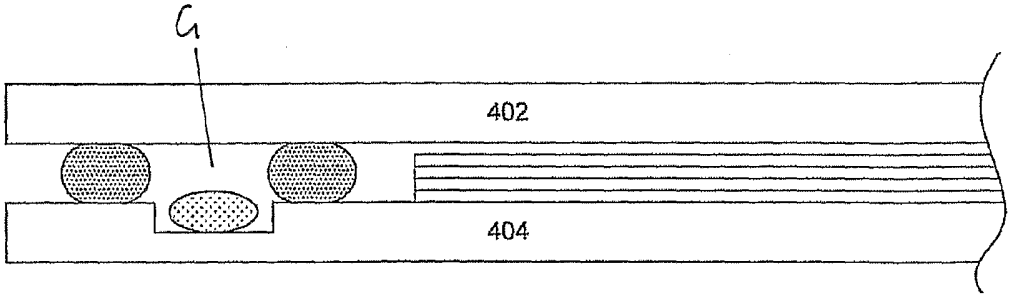

(57) Abstract: The present invention relates to organic electro-luminescent devices, in particular to methods of increasing device lifetime in organic-electro luminescent devices. We will describe an organic electroluminescent device comprising a substrate, a first electrode layer overlying said substrate, an electroluminescent layer overlying said first electrode layer, a second electrode layer overlying said electroluminescent layer, and an encapsulating layer joined to the substrate to cover the organic electroluminescent layer, wherein said electroluminescent layer is surrounded by a ring of getter material that is disposed in a retaining means provided on or in said substrate and/or said encapsulating layer

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Apparatus and method for increased device lifetime in an organic electro-luminescent device

The present invention relates to organic electro-luminescent devices, in particular to methods of increasing device lifetime in organic-electro luminescent devices.

Organic light emitting diodes (OLEDs) comprise a particularly advantageous form of electro-optic display. They are bright, colourful, fast-switching, provide a wide viewing angle and are easy and cheap to fabricate on a variety of substrates. Organic (which here includes organometallic) LEDs may be fabricated using either polymers or small molecules in a range of colours (or in multi-coloured displays), depending upon the materials used. Examples of polymer-based OLEDs are described in WO 90/13148, WO 95/06400 and WO 99/48160; examples of so called small molecule based devices are described in US 4,539,507.

OLEDs may be deposited on a substrate in a matrix of pixels to form a single or multi-colour pixellated display. A multicoloured display may be constructed using groups of red, green, and blue emitting pixels. In such displays the individual elements are generally addressed by activating row (or column) lines to select the pixels, and rows (or columns) of pixels are written to, to create a display. So-called active matrix displays have a memory element, typically a storage capacitor and a transistor, associated with each pixel whilst passive matrix displays have no such memory element and instead are repetitively scanned to give the impression of a steady image.

At their most basic, organic electroluminescent devices generally comprise an organic light emitting material which is positioned between a hole injecting electrode and an electron injecting electrode. The hole injecting electrode (anode) is typically a transparent tin-doped indium oxide (ITO)-coated glass substrate. The material commonly used for the electron injecting electrode (cathode) is a low work function metal such as calcium or aluminium.

The materials that are commonly used for the organic light emitting layer include conjugated polymers such as poly-phenylene-vinylene (PPV) and derivatives thereof (see, for example, WO-A-90/13148), polyfluorene derivatives (see, for example, A. W. Grice, D. D. C. Bradley, M. T. Bernius, M. Inbasekaran, W. W. Wu, and E. P. Woo, *Appl. Phys. Lett.* 1998, 73, 629, WO-A-00/55927 and Bernius et al., *Adv. Materials*, 2000, 12, No. 23, 1737), polynaphthylene derivatives and polyphenanthrenyl derivatives; and small organic molecules such as aluminium quinolinol complexes (Alq3 complexes: see, for example US-A-4,539,507) and quinacridone, rubrene and styryl dyes (see, for example, JP-A-264692/1988). The organic light emitting layer can comprise mixtures or discrete layers of two or more different emissive organic materials.

Typical device architecture is disclosed in, for example, WO-A-90/13148; US-A-5,512,654; WO-A-95/06400; R.F. Service, *Science* 1998, *279*, 1135; Wudl et al., *Appl. Phys. Lett.* 1998, *73*, 2561; J. Bharathan, Y. Yang, *Appl. Phys. Lett.* 1998, *72*, 2660; T.R. Hebner, C.C. Wu, D. Marcy, M.L. Lu, J. Sturm, *Appl. Phys. Lett.* 1998, *72*, 519); and WO 99/48160; the contents of which references are incorporated herein by reference thereto.

The injection of holes from the hole injecting layer such as ITO into the organic emissive layer is controlled by the energy difference between the hole injecting layer work function and the highest occupied molecular orbital (HOMO) of the emissive material, and the chemical interaction at the interface between the hole injecting layer and the emissive layer. The deposition of high work function organic materials on the hole injecting layer, such as poly(styrene sulfonate)-doped poly (3,4-ethylene dioxythiophene) (PEDOT/PSS), N,N'-diphenyl-N,N'-(2-naphthyl)-(1,1'-phenyl)-4,4'-diamine (NBP) and N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine (TPD), provides "hole transport" layers which facilitate the hole injection into the light emitting layer, transport holes stably from the hole injecting electrode and obstruct electrons. These layers are effective in increasing the number of holes introduced into the light emitting layer.

A cross-section through a basic structure of a typical OLED 100a is shown in Figure 1a. A glass or plastic substrate 102 supports a transparent anode layer 104 comprising, for example, indium tin oxide (ITO) on which is deposited a hole transport layer 106, an electroluminescent layer 108, and a cathode 110. The electroluminescent layer 108 may comprise, for example, a PPV (poly(p-phenylenevinylene)) and the hole transport layer 106, which helps match the hole energy levels of the anode layer 104 and electroluminescent layer 108, may comprise a conductive transparent polymer, for example PEDOT:PSS (polystyrene-sulphonate-doped polyethylene-dioxythiophene) from Bayer AG of Germany. Cathode layer 110 typically comprises a low work function metal such as calcium or barium and may include an additional layer immediately adjacent electroluminescent layer 108, such as a layer of lithium fluoride, for improved electron energy level matching. Contact wires 114 and 116 to the anode and the cathode respectively provide a connection to a power source 118. The same basic structure may also be employed for small molecule devices.

In general, OLEDs consist of a multi-layer sandwich of indium-tin-oxide (ITO) as anode contact, one or more organic layers including a light emitting polymer (LEP) layer, and a metal layer as cathode, deposited on a planar substrate, usually of glass or a high refractive index plastic such as polycarbonate. In so-called "bottom emitter" devices, the multi-layer sandwich is deposited on the front surface of a planar glass substrate, with the reflecting electrode layer, usually the cathode, furthest away from the substrate, whereby light generated internally in the LEP layer is coupled out of the device through the substrate. An example of a bottom emitter 100a is shown in Figure 1a, where light 120 is emitted through transparent anode 104 and substrate 102 and the cathode 110 is reflective. Conversely, in a so-called "top emitter", the multi-layer sandwich is disposed on the back surface of the substrate 102, and the light generated internally in the LEP layer 108 is coupled externally through a transparent electrode layer 110 without passing through the substrate 102. An example of a top emitter 100b is shown in Figure 1b. Usually the transparent electrode layer 110 is the cathode, although devices which emit through the anode may also be constructed. The cathode layer 110 can be made substantially transparent by keeping the thickness of the cathode layer less than around 50-100 nm, for example.

However, one problem with organic electro-luminescent devices is that they are sensitive to moisture and gases such as oxygen in the atmosphere, requiring measures to remove water vapour and oxygen from the enclosed space within the package when an OLED device is sealed, and also to prevent water vapour and oxygen from the outside air getting inside the device. UV-curing epoxies may be used to seal OLED devices; however these allow moisture and/or gases such as oxygen to permeate the device, resulting in 'black spots' in the active area where the device no longer emits light.

Providing a getter material which can absorb moisture and/or gases such as oxygen is known in OLED manufacturing methods for preventing moisture and/or other gases reacting with the organic light emitting structure. For example, US 2002/155320, US 5920080, US2004/051449, US 2004/108811 and US 2002/146533. However, previously attention has been focussed on bottom-emitter devices. Such devices often have an opaque top electrode and/or a metal encapsulating can, so it is possible to provide getter material on the inside surface of the encapsulating can above the cathode, without obscuring light from the device.

A focus in the field of OLEDs is the development of 'top-emitting' devices, wherein light emitted from the electroluminescent layer escapes through a transparent cathode rather than through a transparent anode and substrate. Clearly, providing a getter layer arranged over the light emitting layer as per the prior art is not desirable in the case of top-emitting devices. Furthermore, the present inventors have found that the getter in this arrangement can draw water and/or other gases into the cavity in which the light emitting structure is disposed thereby causing degradation of the device structure – the exact process the getter material is there to prevent. We describe herein methods for overcoming these disadvantages with the prior art, particularly suitable in applications involving top-emitting devices but also having advantages when used in conjunction with bottom-emitting devices.

According to one aspect of the present invention, there is provided an organic electroluminescent device comprising: a substrate; a first electrode layer overlying said substrate; an organic electroluminescent layer overlying said first electrode layer; a second electrode layer overlying said electroluminescent layer; an encapsulating layer

joined to the substrate to cover the organic electroluminescent layer; said electroluminescent layer being surrounded by a ring of getter material that is disposed in a retaining means provided on or in said substrate such that a gap is provided between the ring of getter material and the encapsulating layer or on or in said encapsulating layer such that a gap is provided between the ring of getter material and the substrate.

The substrate may comprise any substrate suitable for use in OLED devices, for example a glass sheet or other transparent material such as plastic (e.g. polycarbonate). The electrode layers may comprise low work function metals such as calcium, barium or aluminium. An electron transport layer may be included between the cathode and the electroluminescent layer, for example lithium fluoride. The anode may comprise a transparent conductive material such as indium tin oxide (ITO). A hole transport layer may be included between the anode and the electroluminescent layer, for example a conductive transparent polymer such as PEDOT:PSS, NBP or TPD. The electroluminescent layer may comprise any organic light emitting layer, for example conjugated polymers such as poly-phenylene-vinylene (PPV), polyfluorene derivatives, polynaphthylene derivatives, polyphenanthrenyl derivatives, small organic molecules such as aluminium quinolinol complexes, quinacridone, rubrene and styryl dyes. The organic electroluminescent device may be configured to emit light from the electroluminescent layer through the first electrode layer and the substrate as in a bottom-emitter device, or through the second electrode layer and the encapsulating layer as in a top-emitter device. The encapsulation may comprise a glass sheet or other transparent material such as plastic. In the case of bottom-emitting devices, it may alternatively comprise an opaque material such as a metal can.

The getter material comprises a material that absorbs moisture and/or other atmospheric elements such as gases, for example oxygen. Any material that has these properties may be used. The person skilled in this field will be aware of many such materials. Typical examples include materials such as those described in US 2004/0051449 and US 2002/015530. Preferred examples include alkaline earth materials (e.g. Al, Mg, Zr, Ca, Ta and Ba), oxides or alloys of alkaline earth materials, zeolites and other commercially available getter materials. These are typically provided in a carrier layer, e.g. a UV-curable epoxy resin or acrylate. The adhesive ensures that the getter material stays in

place and can be cured using the same processes as for the adhesive used to bond the substrate and encapsulation together, thereby keeping manufacturing costs down.

The retaining means may comprise any physical means provided on or in the substrate or the encapsulating layer to prevent the getter material from delaminating following expansion caused by swelling of said material after exposure to moisture and the like. It can form a tortuous path for moisture ingression and, for top-emitter devices, can be disposed around the electroluminescent layer without blocking the passage of light therefrom. For example, the retaining means may comprise a trench in the encapsulation or in the substrate, with the getter material in the trench. Alternatively the retaining means may comprise two rings of conventional adhesive material, one surrounding the ring of getter material, the ring of getter material surrounding the other. These may be applied on either the substrate or the encapsulating layer, both as a means for joining the encapsulating layer to the substrate and also as a retaining means for containing the getter material.

The retaining means prevents "squeeze-out" of the getter material when the encapsulation is applied to the substrate for bonding, and confines the getter material. The retaining means also allows for expansion of the getter without loosening the adhesive material and causing the encapsulating layer to delaminate from the substrate.

According to a further aspect of the present invention, there is provided a method of manufacturing a top-emitter organic electroluminescent device, the device comprising a substrate, a first electrode layer overlying said substrate, an organic electroluminescent layer overlying said first electrode layer, a second electrode layer overlying said electroluminescent layer, and an encapsulating layer joined to the substrate to cover the electroluminescent layer, the method comprising: depositing a ring of getter material that is disposed in a retaining means provided on or in said substrate such that a gap is provided between the ring of getter material and the encapsulating layer or on or in said encapsulating layer such that a gap is provided between the ring of getter material and the substrate.

To illustrate the present invention further, we will describe an encapsulated OLED with a getter arrangement that will not cause moisture or oxygen to be drawn into the cavity containing the OLED, that will not result in delamination and that is suitable for transparent OLEDs.

As will be described, this is achieved by disposing getter in a trench around the OLED. The trench may be provided in the substrate and/or the encapsulant as shown in the figures. Alternatively, the trench may be formed from structures formed on the substrate as shown in the Figures. In one embodiment the bumping lines may be formed by depositing two lines of adhesive, curing the adhesive, depositing a getter/adhesive mixture in the resultant trench and then placing the encapsulant thereover. We will describe an encapsulated transparent OLED with a ring of getter around the OLED, with and without a trench.

According to the present invention, the getter is dispensible and is patternable. To enable a dispensible getter, the getter is preferably an adhesive getter. However, any medium such as a gel that can harden and aid deposition of the getter can be used. The getter can be deposited in a patterned form around the OLED in a square, circular, oval or other linear or non-linear configuration as required.

These and other aspects of the present invention will now be further described, by way of example only, with reference to the accompanying drawings in which:

Figure 1a shows a bottom-emitting organic light emitting diode as known in the art.

Figure 1b shows a top-emitting organic light emitting diode as known in the art.

Figure 2a shows a plan view of an encapsulating cover sheet for an organic light emitting diode according to the present invention.

Figure 2b shows the encapsulating cover sheet of Figure 2a at a first stage of manufacture according to the present invention.

Figure 2c shows an encapsulating cover sheet of Figure 2a at a second stage of manufacture according to the present invention.

Figure 2d shows a plan view of an encapsulated organic light emitting diode according to the present invention incorporating the encapsulating cover sheet of Figure 2a.

Figure 2e shows a cross section view of the encapsulated organic light emitting diode according to the present invention of Figure 2d.

Figure 3a shows a plan view of an alternative encapsulating cover sheet for an organic light emitting diode according to the present invention.

Figure 3b shows a cross section view of the encapsulating cover sheet of Figure 3a.

Figure 3c shows a cross section view of the encapsulating cover sheet of Figure 3b at a further stage of manufacture.

Figure 3d shows a cross section view of the encapsulating cover sheet of Figure 3c at a yet further stage of manufacture.

Figure 3e shows a cross section view of an organic light emitting diode according to the present invention incorporating the encapsulating cover sheet of Figure 3d.

Figure 4a shows a cross section view of an alternative organic light emitting diode according to the present invention.

Figure 4b shows a cross section view of a further alternative organic light emitting diode according to the present invention.

Figure 5a shows a plan view of yet further alternative organic light emitting diodes according to the present invention.

Figure 5b shows a cross section view of a first organic light emitting diode according to the plan view of Figure 5a, according to the present invention.

Figure 5c shows a cross section view of a second organic light emitting diode according to the plan view of Figure 5a, according to the present invention.

Figure 5d shows a cross section view of a third organic light emitting diode according to the plan view of Figure 5a, according to the present invention.

Figure 5e shows a cross section view of a fourth organic light emitting diode according to the plan view of Figure 5a, according to the present invention.

Figure 2a shows a plan view of an encapsulation cover glass 200 with adhesive material 202 and adhesive material incorporating a getter 204 applied in surrounding rings. These are suitable for surrounding the perimeter of an OLED device on a substrate. Suitable getters include BaO, CaO, $CaSO_4$, $CaCl_2$, Si, Al_2O3, SiO_2, Ba, Ca, Mg, Ti, Al, Zr, Ta and ZnO. Alternatively agents such as zeolite or silica gel may be used. Other materials may be provided to absorb oxygen and/or other gases. An example method of manufacturing this structure will now be described.

Two rings of a conventional adhesive 202 are dispensed on the cover glass 200 as shown in Figure 2b. These are pre-cured or configured as a spacer in this configuration to form two rings disposed within which is a trench. The adhesive with the getter 204 is then dispensed inside the trench as shown in Figure 2c. The substrate is applied thereto and a plan view of the overall structure is shown in Figure 2d. The trench prevents "squeeze-out" and confines the adhesive. The whole assembly is now cured. Figure 2e shows a cross section view of the assembly.

As best seen with reference to Figure 2e, a gap G is provided between the getter 204 and the substrate 206. The adhesive incorporating the getter therefore has room to expand between the substrate 206 and the cover glass 200 without making contact with both the cover glass 200 and the substrate 206. In this way, any expansion of the adhesive incorporating the getter is prevented from forcing the device apart and causing

subsequent damage of the device. The gap G may be achieved by depositing a comparatively smaller height of getter-incorporating adhesive as compared with the conventional adhesive either side thereof. The conventional adhesive may incorporate filler elements such as silica or glass fibre spacers, and these may be omitted from the adhesive containing the getter.

Alternatively, a trench may be etched directly in the encapsulation sheet. Figure 3a shows a cover glass 300 incorporating a perimeter trench 302 etched out of the glass, for example by sand-blasting. Figure 3b shows a cross section of an etched cover glass. Note that the depth and shape of the trench is merely indicative and other depths and shapes are possible. Perimeter rings of conventional adhesive 304 may be applied on either side of the trench as shown in Figure 3c and adhesive containing the getter 306 may be applied in the trench. The whole structure is then applied to the substrate 308 as shown in Figure 3e. As best seen with reference to Figure 3e, a gap G is provided between the getter 306 and the substrate 308. Using this structure may provide more room for expansion of the adhesive containing the getter or for a greater quantity of getter material than possible without a trench in the encapsulation sheet. The adhesive containing the getter can therefore expand without making contact with both the cover glass 300 and the substrate 308. In this way, any expansion of the adhesive incorporating the getter is prevented from forcing the device apart and causing subsequent damage of the device.

Figure 4a shows an alternative embodiment of the invention similar to Figure 2e, whereby the adhesive material has been applied to the substrate 400 instead of the encapsulation sheet 402 before bonding. The rings of conventional adhesive still contact both surfaces but the adhesive containing the getter may not contact the encapsulation sheet 402 in this example. As before, this allows for expansion of the getter material when moisture or gases such as oxygen are absorbed, without causing delamination of the overall structure.

Figure 4b shows an alternative embodiment of the invention similar to Figure 3e, whereby the trench has been etched in the substrate 404 instead of the encapsulation

sheet 402. Again, this alternative embodiment provides the same advantages as for the encapsulation sheet 402 incorporating a trench.

In a further embodiment of the invention, a ring of adhesive containing getter material may be provided around a top-emitter OLED device and a single ring of conventional adhesive material may be provided around the getter-containing adhesive. Figure 5a shows a plan view of this structure and Figures 5b and 5c show alternative cross section views. In this example there is no second ring of conventional adhesive providing an adhesive trench. The getter-containing adhesive may be applied leaving room for expansion, either to the encapsulation 502 as shown in Figure 5b or to the substrate as shown 500 in Figure 5c, and in these examples there is more room for the getter-containing adhesive to expand laterally. These embodiments may also allow for a greater aperture ratio of an overall OLED display, as the adhesive and getter-containing adhesive may occupy a smaller area than the previous examples, due to the absence of a second ring of conventional adhesive.

Figures 5d and 5e show yet further embodiments wherein a single ring of conventional adhesive bonds the substrate and encapsulation together, as in the previous examples, and wherein a perimeter trench is provided for the getter material, either in the encapsulation sheet 504 as shown in Figure 5d or in the substrate 506 as shown in Figure 5e. This may provide better confinement of the getter-containing adhesive than in the embodiments without a trench, while also providing the advantages of better aperture ratio of those embodiments. These two examples are suitable for both top-emitters and bottom-emitters.

In a yet further embodiment, a portion of the encapsulation sheet 504 of Figure 5d or the substrate 506 of Figure 5e may be removed. The portion may be removed by a chemical mill for example.

Referring to Figure 5d, a dashed line A indicates that around 100 micrometres has been removed from the encapsulation sheet 504 in the region of the electroluminescent material. Referring to Figure 5e, the dashed line indicates that around 100 micrometres has been removed from the substrate 506 in the region of the electroluminescent

material. Such a removal provides greater "headroom" between a cathode layer of the electroluminescent device and the encapsulation sheet 502, 504. The created space can be used to accommodate an optical coupling device in order to reduce light losses between the cathode layer and the encapsulation sheet in the case of top-emitting device. An optical coupling device can be a silica gel or an anti-reflective coating.

It should be appreciated that the practice of removing a portion of the encapsulation sheet or the substrate could be applied to any of the examples illustrated in accordance with the embodiments of the present invention.

Additionally or alternatively, a further trench or cavity can be provided adjacent the conventional adhesive as shown by a dashed line B in Figures 5d and 5e. The further trench or cavity may be provided on either side, which is the electroluminescent material side or the other side; or both sides, of the conventional adhesive. The further trench or cavity provides a means of accommodating any excess conventional adhesive.

Again, it should be appreciated that the practice of providing a further trench or cavity adjacent the conventional adhesive could be applied to any of the examples illustrated in accordance with the embodiments of the present invention.

No doubt many other effective alternatives will occur to the skilled person. It will be understood that the invention is not limited to the described embodiments and encompasses modifications apparent to those skilled in the art lying within the spirit and scope of the claims appended hereto.

CLAIMS:

1. An organic electroluminescent device comprising:

a substrate;

a first electrode layer overlying said substrate;

an organic electroluminescent layer overlying said first electrode layer;

a second electrode layer overlying said electroluminescent layer;

an encapsulating layer joined to the substrate to cover the organic electroluminescent layer; said organic electroluminescent layer being surrounded by a ring of getter material that is disposed in a retaining means provided on or in said substrate such that a gap is provided between the ring of getter material and the encapsulating layer or on or in said encapsulating layer such that a gap is provided between the ring of getter material and the substrate.

2. A device according to claim 1, wherein the retaining means comprises a first ring of adhesive provided on said substrate and/or said encapsulating layer surrounding said electroluminescent layer and a second ring of adhesive surrounding the first ring of adhesive.

3. A device according to claim 1, comprising a first ring of adhesive provided on said substrate and/or said encapsulating layer for joining the encapsulating layer to the substrate and wherein the retaining means comprises a trench in said substrate and/or said encapsulating layer.

4. A device according to claim 3, wherein the first ring of adhesive is provided on a side of the getter material furthest from the electroluminescent layer.

5. A device according to claim 3 or claim 4, wherein a trench or cavity is provided adjacent to the first ring of adhesive.

6. A device according to claim 2, wherein a trench or cavity is provided adjacent the first and/or second ring of adhesive.

7. A device according to any one of claims 1 to 6, wherein the encapsulating layer comprises a metal can.

8. A device according to any one of claims 1 to 7, wherein the getter material comprises a UV-curable epoxy resin loaded with a getter or a thermal set sear light getter.

9. A device according to any one of claims 1 to 8, wherein the ring of getter material comprises a square, circular or oval configuration around the electroluminescent layer.

10. A device according to any one of claims 2 to 9, wherein a first region of the encapsulating layer adjacent the electroluminescent layer is thinner than a second region of the encapsulating layer adjacent the adhesive.

11. A device as claimed in claim 10, wherein the first region is in the range 75 to 150 micrometres thinner than the second region.

12. A device as claimed in claim 11, wherein the first region of the encapsulating layer is around 100 micrometres thinner than the second region.

13. A device according to any one of the preceding claims, wherein an optical coupling device is disposed on the encapsulating layer in a region above or below the electroluminescent layer.

14. A device as claimed in claim 13, wherein the optical coupling device is a silica gel or an anti-reflective coating.

15. A device according to any one of claims 1 to 14, wherein the device comprises a top-emitter.

16. A device according to any one of claims 1 to 14, wherein the device comprises a bottom-emitter.

17. A device according to any one of the preceding claims wherein the organic electrolumiscent layer comprises an organic electroluminescent polymer.

18. A display incorporating the device of any one of claims 1 to 17.

19. A method of manufacturing a top-emitter organic electroluminescent device, the device comprising a substrate, a first electrode layer overlying said substrate, an organic electroluminescent layer overlying said first electrode layer, a second electrode layer overlying said electroluminescent layer, and an encapsulating layer joined to the substrate to cover the electroluminescent layer, the method comprising:

depositing a ring of getter material that is disposed in a retaining means provided on or in said substrate such that a gap is provided between the ring of getter material and the encapsulating layer or on or in said encapsulating layer such that a gap is provided between the ring of getter material and the substrate.

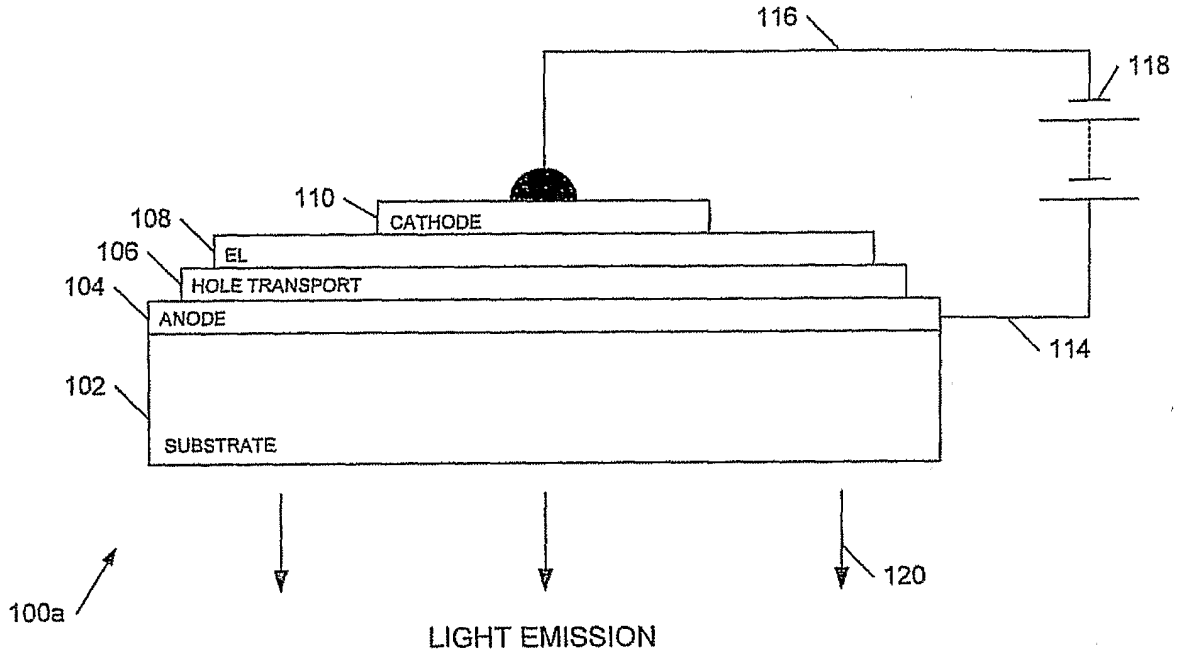

Figure 1a
(PRIOR ART)

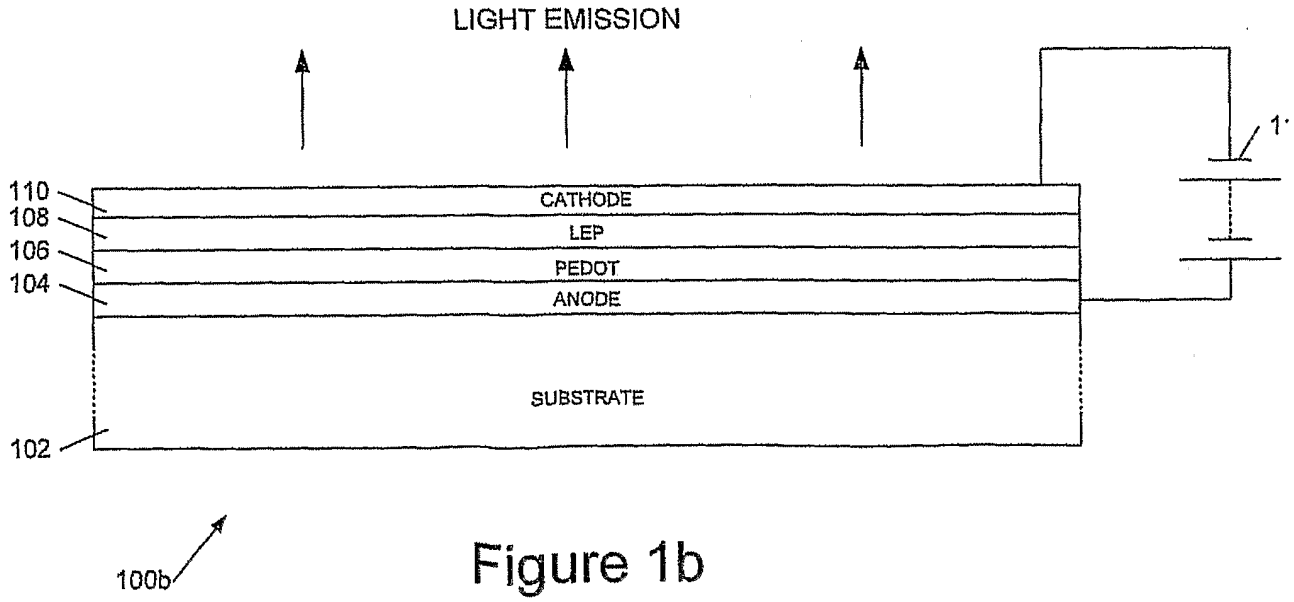

Figure 1b
(PRIOR ART)

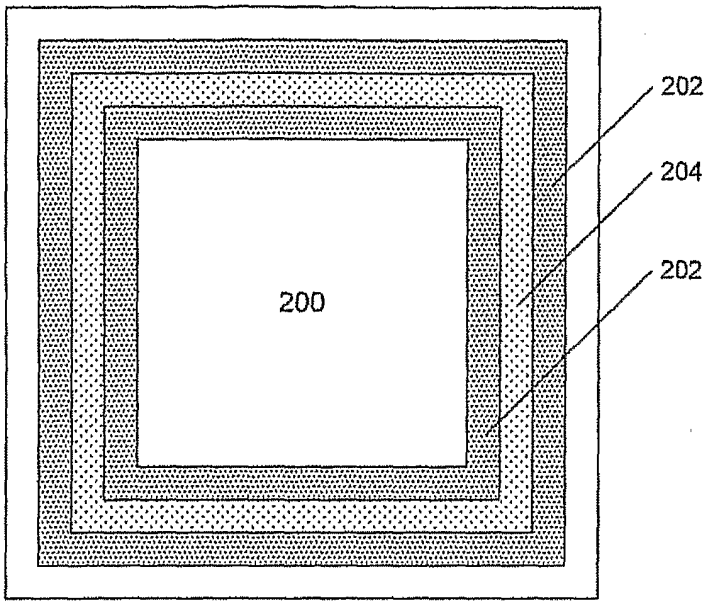

Figure 2a

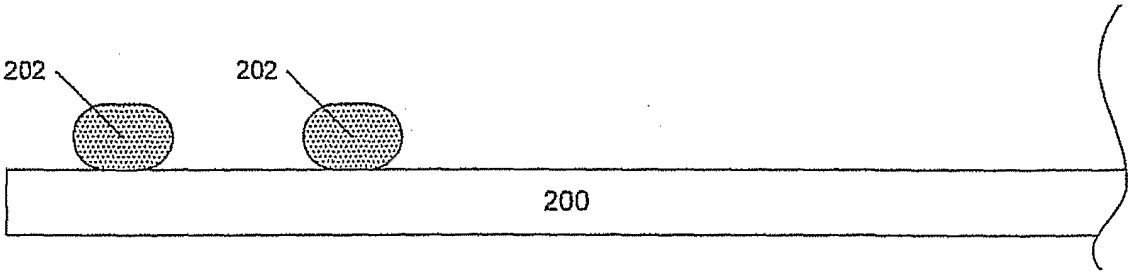

Figure 2b

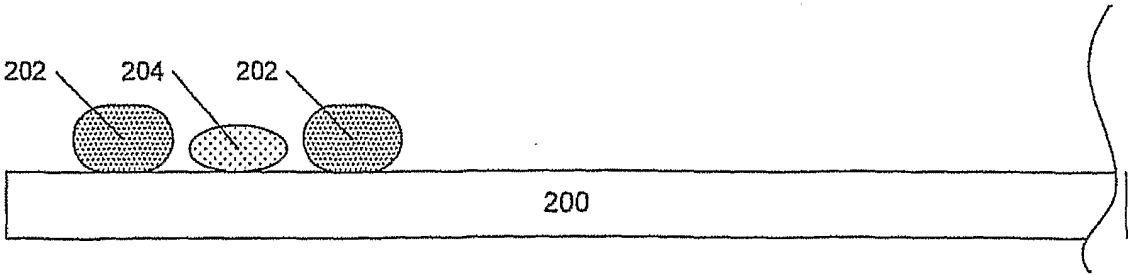

Figure 2c

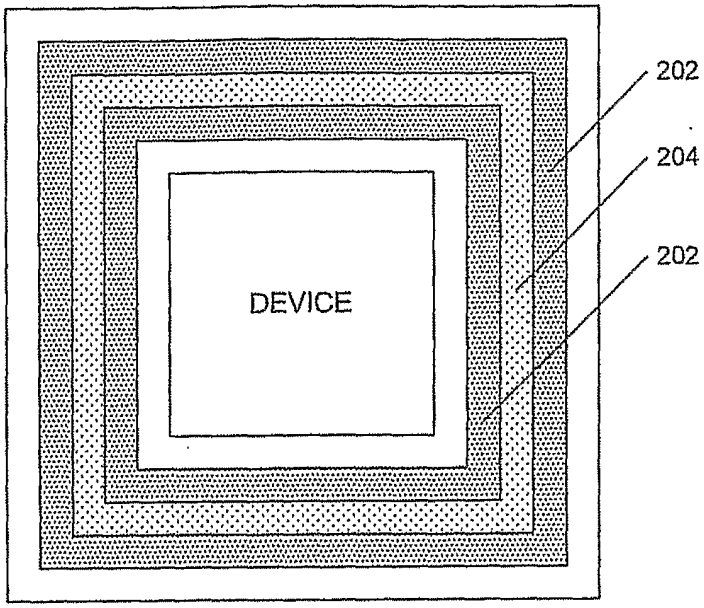

Figure 2d

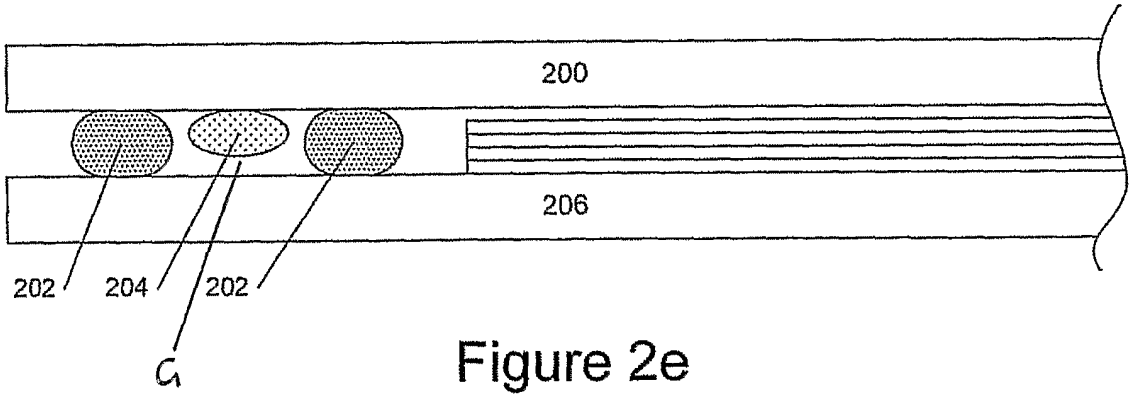

Figure 2e

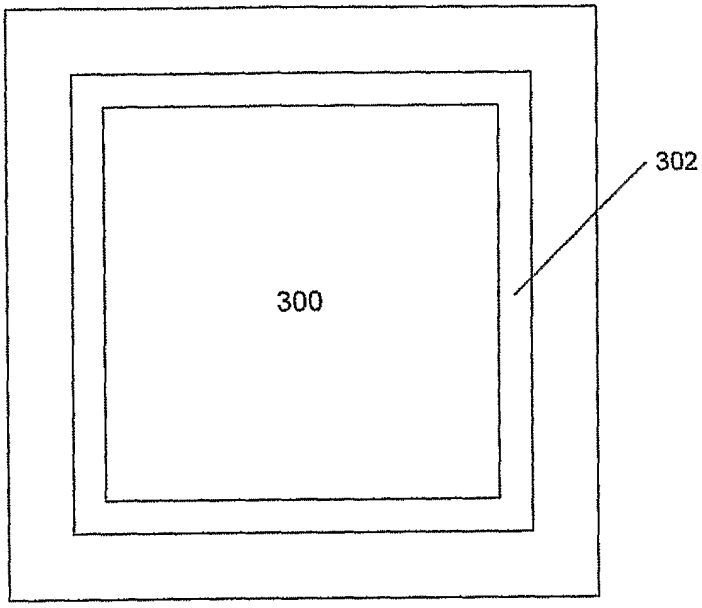

Figure 3a

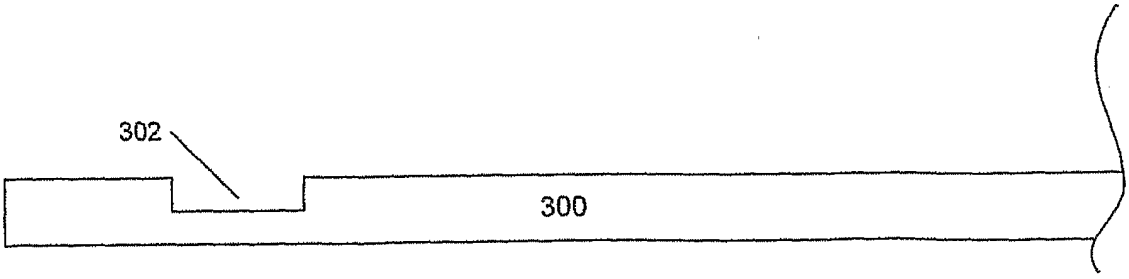

Figure 3b

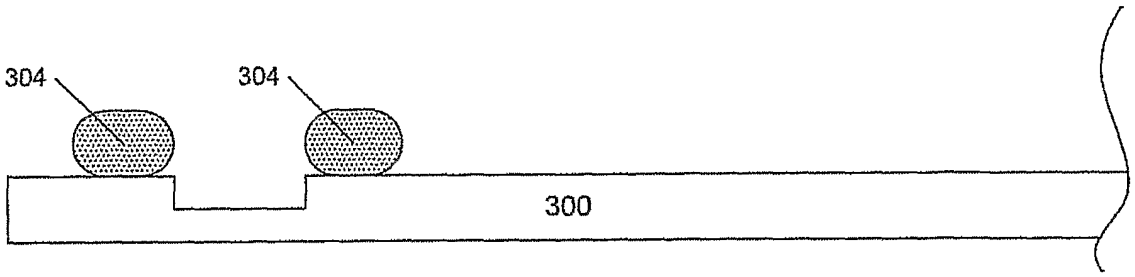

Figure 3c

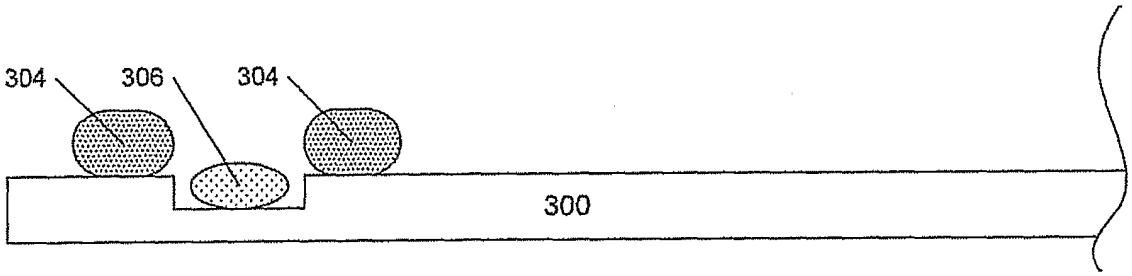

Figure 3d

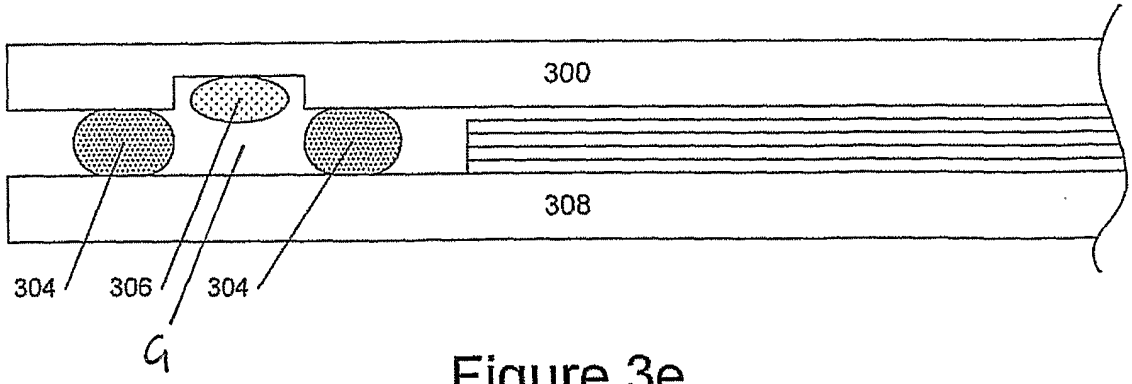

Figure 3e

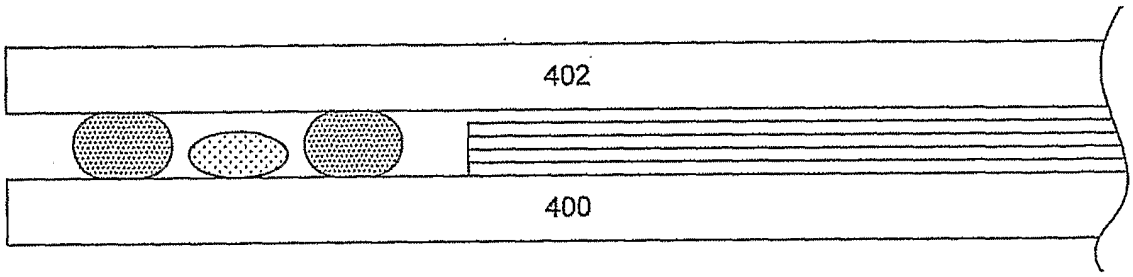

Figure 4a

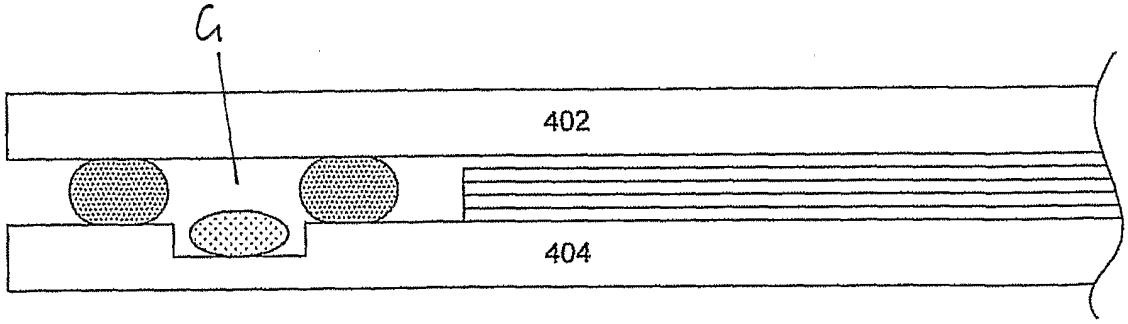

Figure 4b

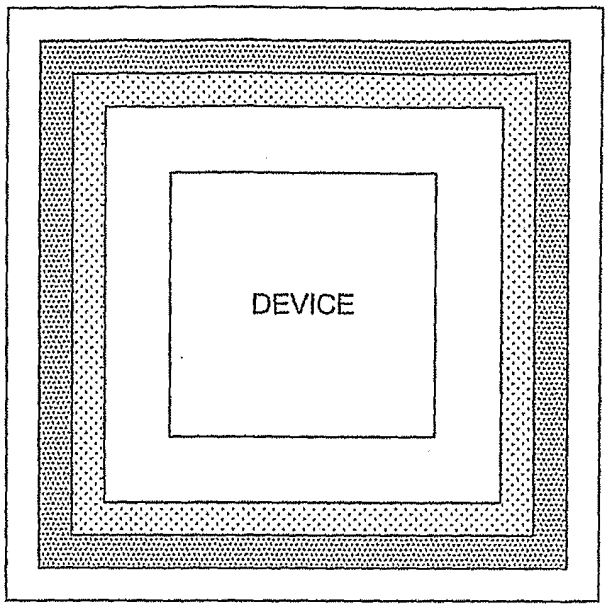

Figure 5a

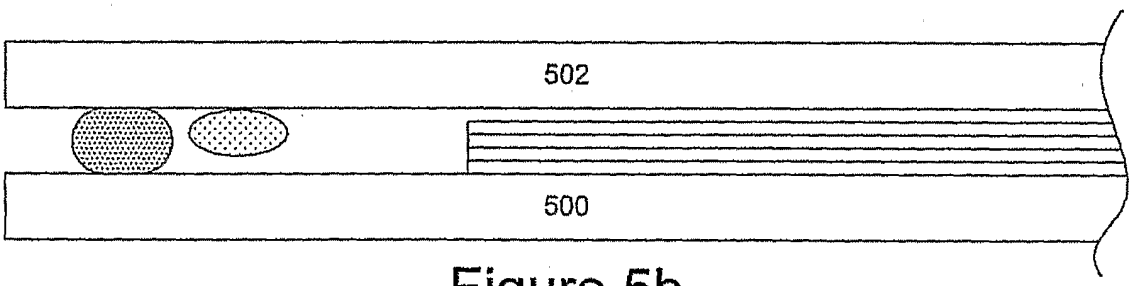

Figure 5b

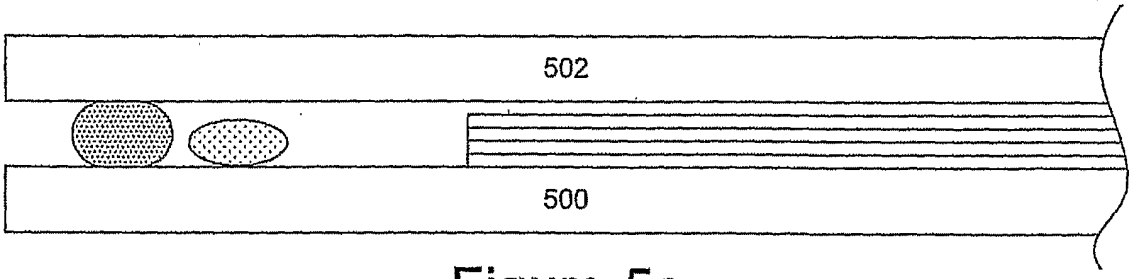

Figure 5c

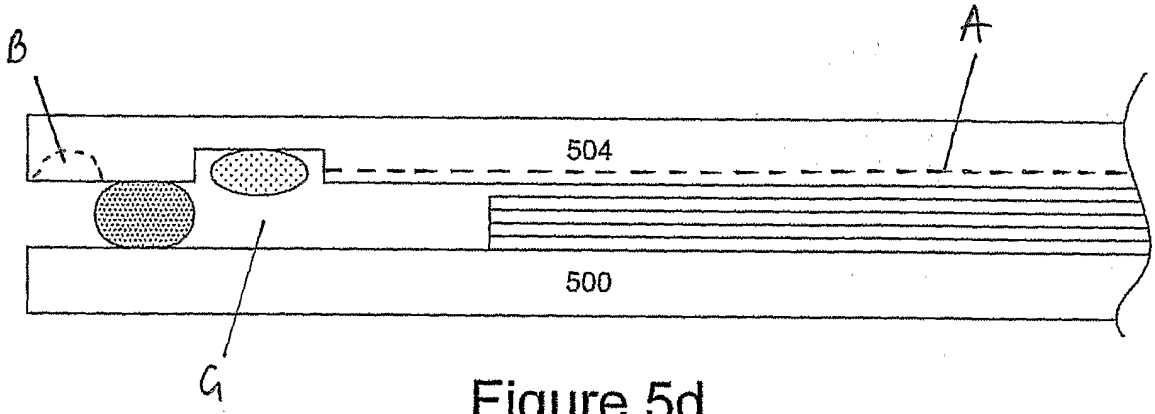

Figure 5d

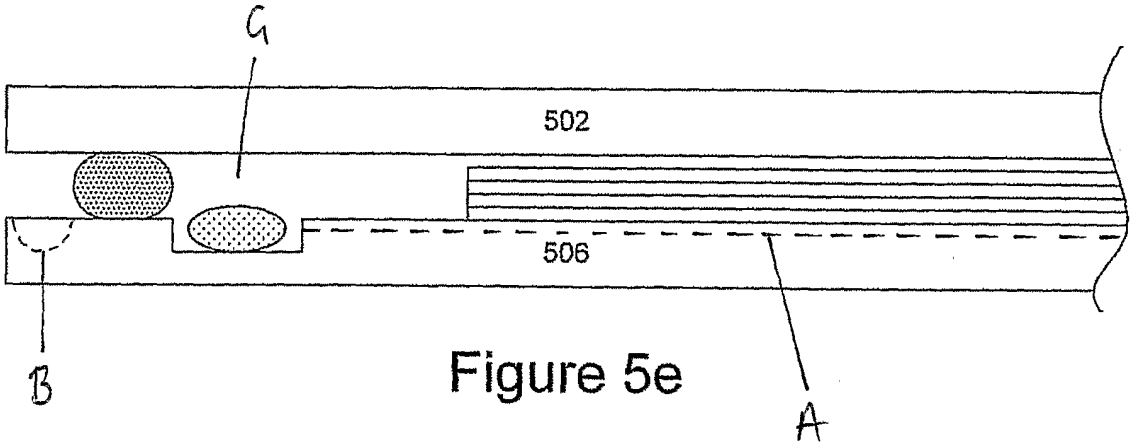

Figure 5e

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
CDT626WO		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB2006/000968	17/03/2006	22/03/2005
Applicant		
CAMBRIDGE DISPLAY TECHNOLOGY LIMITED		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 5 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      [X] the international application in the language in which it was filed
      [ ] a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. [ ] **Certain claims were found unsearchable** (See Box No. II)

3. [ ] **Unity of invention is lacking** (see Box No III)

4. With regard to the **title,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   [ ] the text is approved as submitted by the applicant
   [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings,**
   a. the figure of the **drawings** to be published with the abstract is Figure No. 4b
      [X] as suggested by the applicant
      [ ] as selected by this Authority, because the applicant failed to suggest a figure
      [ ] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2006/000968

Box No. IV Text of the abstract (Continuation of item 5 of the first sheet)

The present invention relates to organic electro-luminescent devices, in particular to methods of increasing device lifetime in organic-electro luminescent devices. We will describe an organic electroluminescent device comprising a substrate (404), a first electrode layer overlying said substrate, an electroluminescent layer overlying said first electrode layer, a second electrode layer overlying said electroluminescent layer, and an encapsulating layer (402) joined to the substrate to cover the organic electroluminescent layer, wherein said electroluminescent layer is surrounded by a ring of getter material (204) that is disposed in a retaining means (202) provided on or in said substrate and/or said encapsulating layer

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2006/000968

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L51/52 H01L23/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 6 081 071 A (ROGERS ET AL) 27 June 2000 (2000-06-27) column 2, line 57 - column 4, line 33; figures 2-4	1,2,9, 15,16, 18,19 3-6, 10-14
X	US 2005/045900 A1 (SILVERNAIL JEFFREY ALAN) 3 March 2005 (2005-03-03) paragraphs [0039] - [0046], [0060]; figures 3a,b,7	1,7,9, 15,16, 18,19
Y	US 2005/046349 A1 (TANAKA ATSUSHI ET AL) 3 March 2005 (2005-03-03) paragraphs [0005] - [0008]; figures 3b,4	3-6

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 June 2006	04/07/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bakos, T

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2006/000968

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2003/067268 A1 (MATSUOKA HIDEKI) 10 April 2003 (2003-04-10) paragraphs [0029], [0033]; figures 5d,6b	10-12
Y	US 2003/170496 A1 (HIEDA SHIGERU ET AL) 11 September 2003 (2003-09-11) paragraphs [0050] - [0053], [0076], [0080]; figures 1,2; example 3	13,14

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2006/000968

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6081071 A	27-06-2000	NONE	
US 2005045900 A1	03-03-2005	NONE	
US 2005046349 A1	03-03-2005	CN 1592509 A JP 2005071639 A	09-03-2005 17-03-2005
US 2003067268 A1	10-04-2003	CN 1411323 A	16-04-2003
US 2003170496 A1	11-09-2003	JP 2003264061 A	19-09-2003