



(51) International Patent Classification:
H01L 51/52 (2006.01) *H01L 51/00* (2006.01)

(21) International Application Number:
PCT/IB2010/053873

(22) International Filing Date:
30 August 2010 (30.08.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09169467.9 4 September 2009 (04.09.2009) EP

(71) Applicant (for all designated States except DE, US):
KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(71) Applicant (for DE only): **PHILIPS INTELLECTUAL PROPERTY & STANDARDS GMBH** [DE/DE]; Lübeckertordamm 5, 20099 Hamburg (DE).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **LOEBL, Hans-Peter** [DE/DE]; c/o High Tech Campus Building 44, NL-5656 AE Eindhoven (NL). **BOERNER, Herbert, F.** [DE/DE]; c/o High Tech Campus Building 44, NL-5656 AE Eindhoven (NL).

(74) Agents: **BEKKERS, Joost** et al.; High Tech Campus Building 44, NL-5656 AE Eindhoven (NL).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: OLED DEVICE WITH LOW INDEX MATERIAL

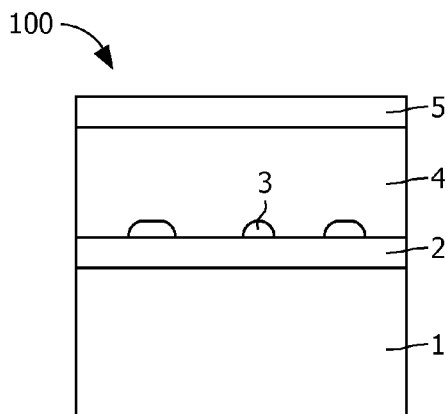


FIG. 8

(57) Abstract: The invention relates to an OLED device(100) and a method for manufacturing it, said OLED device(100) comprising a first electrode layer(2), an organic electroluminescent layer(4), and a second electrode layer(5). Moreover, a low-index material(3) is disposed on the first electrode layer(2) and embedded in the organic electroluminescent layer(4). The low-index material(3) may particularly comprise SiO₂ and be arranged in a regular or an irregular pattern, preferably in a pattern of islands(3).

OLED DEVICE WITH LOW-INDEX MATERIAL

5 FIELD OF THE INVENTION

The invention relates to an OLED device and a method for its production, said OLED device comprising a low-index intermediate material.

BACKGROUND OF THE INVENTION

10 From the US 2008/0265757 A1, an Organic Light Emitting Diode (OLED) device is known which comprises common OLED components like a transparent substrate, a transparent ITO anode, an organic electroluminescent layer, and a cathode. Moreover, a grid of silicon dioxide (SiO_2) is disposed on the ITO layer in order to improve the outcoupling of light into the substrate.

15

SUMMARY OF THE INVENTION

Based on this background it that was an object of the present invention to provide a simplified design and manufacturing procedure for an OLED device having a high efficiency.

20

This object is achieved by an OLED device according to claim 1 and a method according to claim 2. Preferred embodiments are disclosed in the dependent claims.

According to a first aspect, the invention relates to an OLED device comprising the following sequence of components:

a) A first electrode layer to which a first electrical potential can be
25 applied during operation. Moreover, the first electrode layer will preferably be transparent to allow the passage of light. It may for example consist of ITO.

b) A material having an index of refraction that is lower than the index of refraction of the subsequent organic electroluminescent layer which will be mentioned next. For this reason, said material will in the following shortly be called "low-index
30 material". Typical values of the refractive index of the low-index material range between about 1.3 and about 1.7. Moreover, the low-index material will usually be transparent.

The low-index material is arranged on the first electrode layer in an irregular pattern and/or a pattern of "islands". The term "islands" shall denote in this context small, unconnected regions or spots of material.

5 c) An organic electroluminescent layer that is disposed on the first electrode layer with the low-index material, thus (partially) embedding said material. As known to a person skilled in the art of OLEDs, the organic electroluminescent layer may comprise several sub-layers for electron or hole injection, charge transportation and/or light generation. Suitable examples of such layers may be found in literature (e.g. Shinar, Joseph (Ed.), "Organic Light-Emitting Devices: A Survey", NY: Springer-Verlag (2004); Klaus
10 Muellen, Ullrich Scherf (Eds.), "Organic Light Emitting Devices: Synthesis, Properties and Applications", John Wiley & Sons (2006)).

d) A second electrode layer to which, during operation, a second electrical potential can be applied. In many cases said second electrical potential will be higher than the first electrical potential applied to the first electrode layer, making the latter
15 operate as an anode and the second electrode operate as a cathode.

According to a second aspect, the invention relates to a method for manufacturing an OLED device, particularly an OLED device of the aforementioned kind. The method comprises the following steps, which are preferably executed at least once in the listed sequence:

20 a) The provision of a first electrode layer.
b) The deposition of a "low-index material" on said first electrode layer, particularly in an irregular pattern and/or a pattern of islands.

c) The deposition of an organic electroluminescent layer on the first electrode layer with the low-index material, wherein the deposited organic material has a
25 higher refractive index than the low-index material.

d) The deposition of a second electrode layer on the aforementioned organic electroluminescent layer.

With this method, an OLED device of the kind described above can be produced. Reference is hence made to the above description for more information and
30 explanations about the method.

The OLED device and the method make use of a low-index material disposed on a first electrode layer and embedded in a subsequent organic electroluminescent layer. Functionally, this material has the positive effect to improve the light outcoupling from the organic layer into the first electrode layer and a substrate beneath it. Moreover, the irregular

and/or island pattern of the material can readily be manufactured by various methods, allowing to keep production costs of the OLED device low.

In the manufacturing method, the step b) of depositing a low-index material on the first electrode layer may particularly comprise the following sub-steps:

5 b1) Depositing a photoresist layer on the first electrode layer. Suitable photoresist materials (e.g. SU-8) and procedures to deposit them are known to a person skilled in the art. It should be noted that "positive" and "negative" photoresist materials can be distinguished. In negative photoresist materials, regions exposed to light (and heated afterwards) stabilize and hence remain after development. In positive photoresist materials,
10 on the contrary, regions exposed to light become soluble, and it are the unexposed regions which remain after development.

 b2) Opening the deposited photoresist layer to provide holes that expose the underlying first electrode layer.

 b3) Depositing a layer of low-index material over the opened photoresist
15 layer. Low-index material will hence enter into the holes generated in the previous step and contact the surface of the first electrode layer.

 b4) Removing the (remaining) photoresist layer. In this step, any low-index material that resides on top of photoresist material will be removed, too.

 As a result of these steps, a pattern of the low-index material will remain on
20 the first electrode layer at the positions of the holes that were generated in the photoresist layer.

 In the aforementioned embodiment of the manufacturing process, the step b2) of opening the photoresist layer to create holes may particularly comprise exposing the photoresist layer locally to light and removing subsequently the exposed or unexposed
25 regions of this layer. In case a negative photoresist is used, regions of the photoresist material are removed that were not exposed to light. In case a positive photoresist is used, regions of the photoresist material are removed that were exposed to light.

 In the aforementioned embodiment of the manufacturing process, the selective local exposure of the photoresist layer to light can be done in several ways. According to a
30 first alternative, the exposure to light is done through a suitable mask. This mask may for example be a metal sheet with holes at positions where the photoresist layer shall be irradiated. In this case a positive photoresist will typically be used. These holes in the metal mask can be fabricated easily and cost effective e.g. by means of a laser.

According to another embodiment of the manufacturing process, the photoresist layer may comprise opaque particles, wherein these particles may for example comprise small colored and/or non-transparent glass beads in the size of about 0.5 μm to about 10 μm . The diameters and/or the average mutual distances of the opaque particles typically lie in the range of the desired diameters of the holes in the photoresist layer. When the photoresist layer is exposed to light, the particles shadow the photoresist material below them. In case a positive photoresist is used, the corresponding shadowed regions will later remain while the rest of the photoresist (and the particles) can be removed.

As described above, the low-index material can be applied onto the first electrode layer by a photolithographic technique. According to another embodiment of the manufacturing method, step b) of depositing comprises the sub-step of spraying a low-index material onto the first electrode layer. As usual, the term "spray" shall denote an aerosol comprising droplets with the low-index material or a precursor thereof. Structures (e.g. islands) of low-index material will then develop from such droplets after their deposition on the first electrode layer. The size and density of the structures can hence readily be controlled via the parameters of the spray (droplet size, droplet density etc.). The spray conditions may for example be chosen such that islands with a size (diameter) between about 0.5 μm and about 30 μm are generated. The spraying procedure automatically guarantees that the resulting structures have a smooth shape without steep edges, such that the organic layers and the metals of the second electrode can be deposited by e.g. vacuum evaporation without creating cracks or holes.

The material of the aforementioned spray may for example comprise a suitable polymer solution. Suitable materials for the polymer comprise amorphous fluoropolymers (e.g. one of the Teflon AF® series of DuPont). These polymers are preferred because of their low refractive index of typically 1.29 to 1.31. Appropriate solvents for the polymers comprise for example fluorocarbon-based coolant liquids. The polymer solution may be sprayed with an airbrush or a similar device on the first electrode layer.

According to another embodiment, the spray may comprise a precursor of a sol-gel process. Sol-gel polymerization may particularly comprise the use of an ultrasonically sprayed aerosol with such a precursor. Typical examples of precursors are acidid solutions comprising **tetraethyl orthosilicate** (TEOS) (TEOS : ethanol : water : HCl).

After spraying, the low-index material is preferably cured, i.e. its chemical and/or physical state is altered at elevated temperatures and/or in a special atmosphere. A deposited spray comprising a polymer solution may for example be dried and backed

according to the manufactures specification to achieve structures of hardened polymer that do not contain any solvent. Sprayed droplets of a sol-gel precursor may for example receive a bakeout at temperatures above about 80° C to form SiO₂ islands with a low index of refraction of about 1.4.

Islands of the low-index material may have equal sizes and shapes or different sizes and shapes. Moreover, the islands may be arranged in a regular pattern or in an irregular pattern on the first electrode layer. In general, irregular patterns have the advantage that they may readily be produced (e.g. by distributing opaque particles in the photoresist layer or by spraying) because they require little fine tuning. Moreover, irregular patterns help to avoid optical artifacts like Moiré patterns or other optical effects due to optical interference at a regular grating.

The thickness of the low-index material on the first electrode layer preferably ranges between about 50 nm and about 500 nm, most preferably being about 100 nm ± 10 %, wherein the thickness is measured perpendicularly to the layers of the OLED device.

When the low-index material is arranged in islands, their diameter typically ranges between about 0.1 µm and about 100 µm, preferably between about 1 µm and about 20 µm, most preferably between about 2 µm and about 15 µm, wherein the diameter is measured parallel to the layers of the OLED device.

The area covered by the low-index material may typically range between about 1 and 20 %, preferably between about 2 and 15 %, most preferably between about 5 and 10 % of the area of the first electrode layer.

The refractive index of the low-index material has to be lower than the refractive index of the organic layers (which is typically smaller than about 1.8 - 2.0) and therefore preferably ranges between about 1.3 and about 1.7. In this case the outcoupling efficiency can be optimized.

The low-index material may preferably comprise at least one the following materials: SiO₂ (silicon dioxide), AlF₃, Al₂O₃, BaF₂, CaF₂, CeF₃, CsF, DyF₃, ErF₃, GdF₃, HfF₂, HoF₃, LaF₃, LiF, MgF₂, Na₃AlF₆, Na₅Al₃F₁₄, NaF, NdF₃, PrF₃, ScF₃, SrF₂, YF₃, YbF₃, ZrF₄, amorphous fluoropolymers (e.g. available as Teflon AF® series from DuPont), transparent low k dielectrics (e.g. available as Cyclotene® from Dow Chemical).

The first electrode layer may preferably be disposed on a substrate layer. In general, the substrate may comprise any flexible or rigid material that is suited as a carrier of the subsequent components. Typically, the substrate will be transparent and for example consist of plastic or glass.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter. These embodiments will be described by way of example with the help of the accompanying drawings in which:

5

Figures 1–8 illustrate consecutive steps of the manufacturing of an OLED device according to a photolithographic process;

10

Figures 9 and 10 illustrate consecutive steps of the manufacturing of an OLED device according to a spraying process.

Like reference numbers in the Figures refer to identical or similar components.

DESCRIPTION OF PREFERRED EMBODIMENTS

15

Enhanced light outcoupling of OLEDs using embedded low-index grids on the anode (ITO layer) has been proposed by Y. Sun and S. Forrest (Nature Photonics 2, 483 (2008)). The SiO₂ grid used in this case for light outcoupling has a line-width of approximately 1 μm and a pitch in the order of 5 μm. It is fabricated by depositing SiO₂ first by PECVD and patterning by conventional photolithography (using positive resist, exposure, hard bake, and dissolving the photoresist, thus opening the area in which SiO₂ is chemically etched). This is a relative costly procedure.

20

To provide a simplified method for depositing an outcoupling structure on top of an electrode, it is proposed here to use (instead of a grid) an irregular array of low-index structures or a regular or irregular array of low-index islands, e.g. SiO₂ islands. These structures have a positive effect on optical outcoupling. They can be formed by photolithography. Alternatively, also a rather inexpensive metal mask with small holes can be used to define the area in which photoresist is exposed to light. As another alternative one can add small particles to the photoresist which also serve as a sort of photomask. Moreover, low-index structures can be produced by spraying a suitable polymer solution and/or a precursor aerosol for a sol-gel polymerization.

25

30

The above general concepts will now be explained in more detail with reference to the Figures 1–8, which illustrate consecutive steps of the production of an OLED device 100 in a photolithography process according to the present invention.

As the starting step of the procedure, Figure 1 shows in a side view the provision of a glass substrate 1 on which a first electrode layer 2 (anode) is deposited. The electrode layer typically consists of ITO.

In Figure 2, a photoresist layer 10 has been spun onto the first electrode layer.

5 The subsequent structuring of the photoresist layer 10 may be done in two alternative ways. The first alternative is illustrated in Figure 3a and comprises the arrangement of a metal mask 20 with holes 21 in front of the photoresist layer 10a while this is irradiated with light (cf. arrows). As a result, only the photoresist material underneath the holes 21 is exposed to light. It is assumed in this case that a positive photoresist is used, in
10 which exposed material can later be removed while unexposed material remains.

The second alternative is illustrated in Figure 3b. Here, a positive photoresist with embedded opaque particles 11 is used. When this photoresist layer 10b is exposed to light, the opaque particles 11 shadow the photoresist material beneath them. After exposure (and a hardening step), the particles 11 and the exposed material between and above them can
15 be removed.

Figure 4 shows the stack of layers with the opened photoresist layer 10', i.e. after the removal of the exposed photoresist material (the Figure particularly continues the example of Figure 3a; in case of Figure 3b, the top surfaces of the photoresist-remainders would be more irregular). The opened photoresist layer 10' now comprises a pattern of
20 holes 12.

In Figure 5, a layer of SiO₂ has been deposited, creating islands 3 of SiO₂ in the holes of the photoresist layer 10' and depositions 3' of SiO₂ on the lands of photoresist material. The islands 3 may typically have a thickness of approximately 100 nm.

In the next step, the opened photoresist layer 10' and the SiO₂ material 3' on
25 top of it are stripped in a lift-off-process. As a result, only the islands 3 of SiO₂ remain on top of the first electrode layer 2. This is shown in Figure 6 in the usual side view and additionally in Figure 7 in a top view (seen in direction of arrow VII of Figure 6).

Figure 8 shows a section through the finished OLED device 100 that results after application of an organic electroluminescent layer 4 and an aluminum cathode 5 on the
30 electrode layer 2. The islands 3 of SiO₂ are hence embedded in the organic material 4.

Figures 9 and 10 illustrate an alternative method for generating islands of a low-index material by spraying. As a starting point, Figure 9 shows the provision of a glass substrate 1 with a first electrode layer 2 on top. By (e.g. ultrasonic) spraying, an aerosol of particles 13 is generated above the first electrode layer 2.

The aerosol particles 13 may for example consist of a polymer solution. The polymer may be an amorphous fluoropolymer of the Teflon AF® series of DuPont (e.g. Teflon AF with the order numbers 601S1-100-6, 601S1-1-6, 601S2-100-6, 601S2-1-6, 601S1-100-18, 601S2-100-18, 400S1-100-1, 400S1-1-1). The polymer may be solved in a fluorocarbon-based electronics coolant liquid (e.g. Fluoroinert® FC-72, 77, 75 from 3M; Flutec® PP2, 6, 50 from Rhone-Poulenc; Galden® HT 10, HT 35 from Ausimont).

According to another embodiment, the aerosol particles 13 may be precursors for a sol-gel polymerization. They may for example consist of acidid solutions comprising **tetraethyl orthosilicate** (TEOS : ethanol : water : HCl).

Figure 10 shows the setup after (at least some of) the particles of the aerosol have settled upon the electrode layer 2 and have been cured. In the aforementioned case of a sol-gel polymerization, the curing may for instance comprise heating to temperatures above 80° C, at which the precursor material transforms to SiO₂ with a low index of refraction of 1.4.

Further processing of the device may be done as explained with respect to Figure 8.

In summary, the above examples disclose a method to fabricate very effective low-index outcoupling structures. An SiO₂ structure is deposited on top of an ITO anode of an OLED device and couples ITO and organic modes into the substrate. In contrast to SiO₂ grids, the outcoupling structure of the invention comprises an array of SiO₂ islands and/or an irregular pattern. The manufacturing of the OLED device preferably uses a cheap exposure technique and a simple lift-off process.

Finally it is pointed out that in the present application the term "comprising" does not exclude other elements or steps, that "a" or "an" does not exclude a plurality, and that a single processor or other unit may fulfill the functions of several means. The invention resides in each and every novel characteristic feature and each and every combination of characteristic features. Moreover, reference signs in the claims shall not be construed as limiting their scope.

CLAIMS:

1. An OLED device (100), comprising the following sequence of components:
 - a) a first electrode layer (2);
 - b) a low-index material that is disposed on the first electrode layer in an irregular pattern and/or in a pattern of islands (3);
 - c) an organic electroluminescent layer (4) that is disposed on the first electrode layer (2) and the low-index material (3) and that has a higher refractive index than the low-index material (3);
 - d) a second electrode layer (5).
2. A method for manufacturing an OLED device (100), comprising the following steps:
 - a) provision of a first electrode layer (2);
 - b) depositing a "low-index material" on the first electrode layer;
 - c) depositing an organic electroluminescent layer (4) on the first electrode layer (2) with the low-index material (3), wherein the deposited organic material has a higher refractive index than the low-index material (3);
 - d) depositing a second electrode layer (5) on the organic electroluminescent layer.
3. The method according to claim 2, characterized in that the step b) of depositing a low-index material (3) comprises the following sub-steps:
 - b1) depositing a photoresist layer (10) on the first electrode layer (2);
 - b2) opening said photoresist layer to provide holes (12) exposing the underlying first electrode layer (2);
 - b3) depositing a layer of low-index material (3, 3') over the opened photoresist layer (10');
 - b4) removing the opened photoresist layer (10').

4. The method according to claim 3, characterized in that the step b2) of opening the photoresist layer (10) comprises exposing said photoresist layer locally to light and subsequently removing the exposed or the unexposed regions of photoresist.

5

5. The method according to claim 4, characterized in that the exposure to light takes place through a mask (20).

6. The method according to claim 3,

10 characterized in that the photoresist layer (10) comprises opaque particles (11).

7. The method according to claim 2,

characterized in that the step b) of depositing a low-index material (3) comprises the spraying of a material (13) onto the first electrode layer (2).

15

8. The method according to claim 7,

characterized in that the sprayed material (13) comprises a polymer solution and/or a precursor of a sol-gel process.

20 9. The method according to claim 7,

characterized in that the sprayed material (13) is cured after spraying to yield the low-index material (3).

10. The OLED device (100) according to claim 1 or the method according to

25 claim 2,

characterized in that the low-index material is arranged in a regular or an irregular pattern of islands (3) on the first electrode layer (2).

11. The OLED device (100) according to claim 1 or the method according to

30 claim 2,

characterized in that the thickness of the low-index material (3) ranges between about 50 nm about 500 nm.

12. The OLED device (100) according to claim 1 or the method according to claim 2, characterized in that the low-index material is arranged in islands (3) having a diameter between about 0.1 μm about 100 μm .

5

13. The OLED device (100) according to claim 1 or the method according to claim 2, characterized in that the low-index material (3) covers between about 1 and 20 %, preferably between about 2 and 15 %, most preferably between about 5 and 10 % of the area of the first electrode layer (2).

10

14. The OLED device (100) according to claim 1 or the method according to claim 2, characterized in that the low-index material (3) comprises a material selected from the group consisting of SiO_2 , AlF_3 , Al_2O_3 , BaF_2 , CaF_2 , CeF_3 , CsF , DyF_3 , ErF_3 , GdF_3 , HfF_2 , HoF_3 , LaF_3 , LiF , MgF_2 , Na_3AlF_6 , $\text{Na}_5\text{Al}_3\text{F}_{14}$, NaF , NdF_3 , PrF_3 , ScF_3 , SrF_2 , YF_3 , YbF_3 , ZrF_4 , amorphous fluoropolymers, and transparent dielectrics.

15

15. The OLED device (100) according to claim 1 or the method according to claim 2, characterized in that the first electrode layer (2) is disposed on a substrate (1).

20

1/3

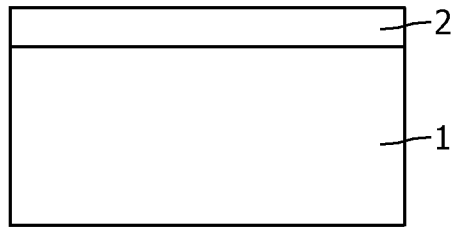


FIG. 1

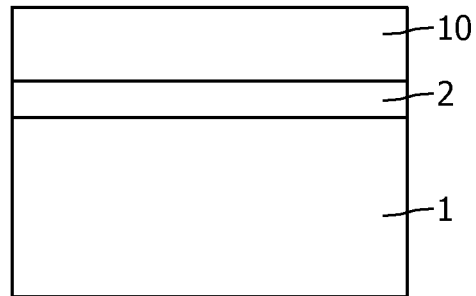


FIG. 2

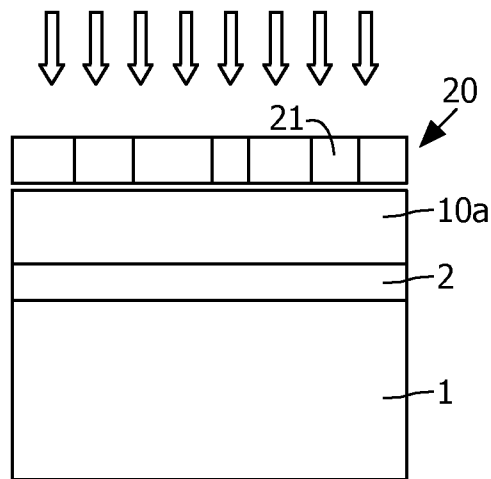


FIG. 3a

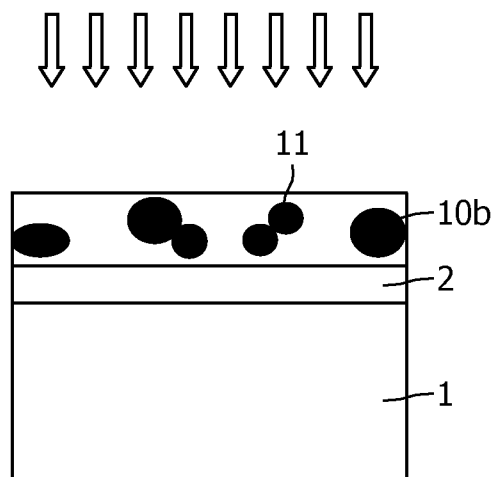


FIG. 3b

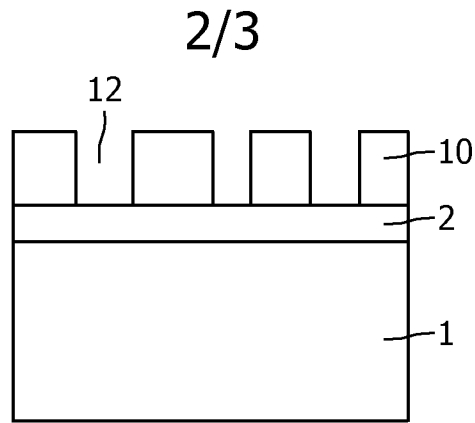


FIG. 4

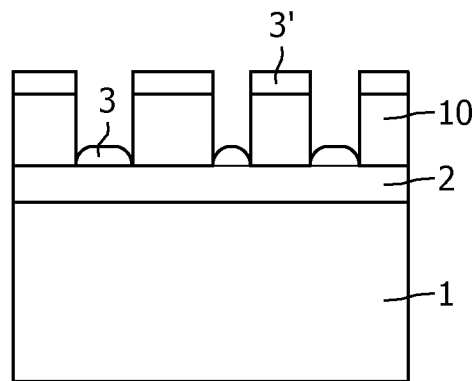


FIG. 5

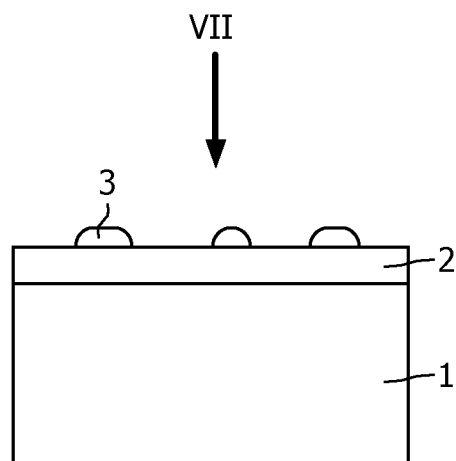


FIG. 6

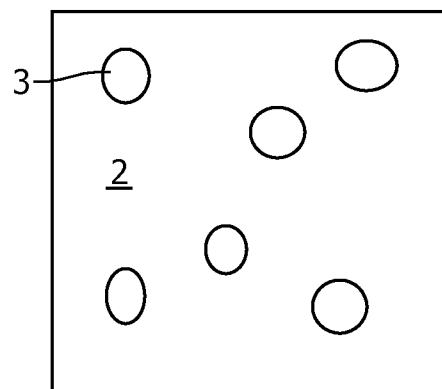


FIG. 7

3/3

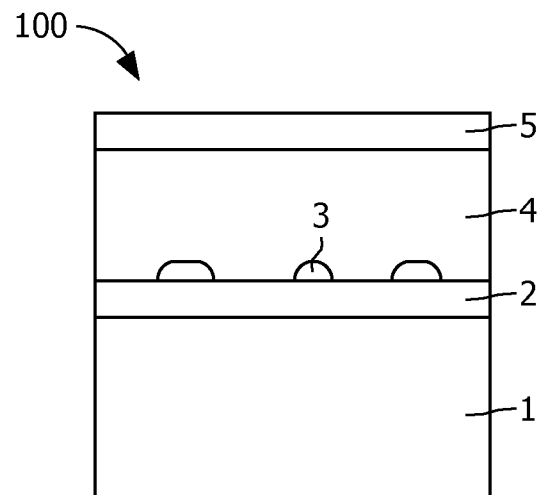


FIG. 8

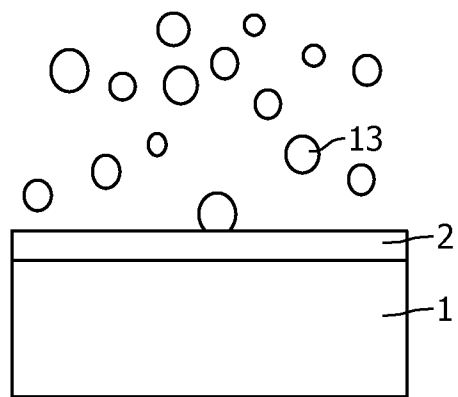


FIG. 9

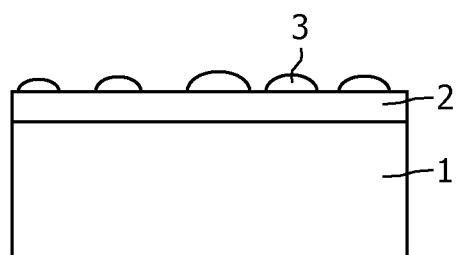


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2010/053873

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01L51/52
ADD. H01L51/00

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	GB 2 400 235 A (QINETIQ LTD [GB]) 6 October 2004 (2004-10-06) pages 5-9; figure 3; examples 1-6	1-15
X	US 2004/188690 A1 (NOGUCHI TAKAFUMI [JP]) 30 September 2004 (2004-09-30) paragraphs [0024] - [0040], [0 55]; figures 2B, 2F, 3G paragraphs [0015] - [0017]	1, 3-12, 15
X	YIRU SUN, STEPHEN R. FORREST: "Enhanced light out-coupling of organic light-emitting devices using embedded low-index grids" NATURE PHOTONICS, vol. 2, 11 July 2008 (2008-07-11), pages 483-487, XP002608855 * abstract pages 484-486; figures 1, 3	1-9, 11-15

☐ Further documents are listed in the continuation of Box C.

☒ 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

11 November 2010

Date of mailing of the international search report

22/11/2010

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Konrádsson, Ásgeir

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2010/053873

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
GB 2400235	A	06-10-2004	WO	2004088766 A1	14-10-2004
US 2004188690	A1	30-09-2004	JP	2004296219 A	21-10-2004