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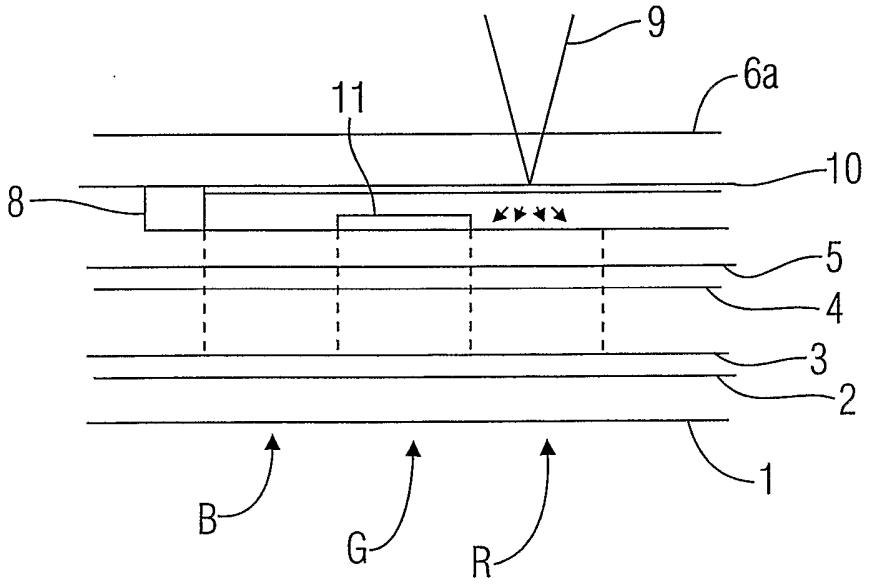
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[Continued on next page]

(54) Title: DISPLAY OF ORGANIC LIGHT-EMITTING DIODES AND METHOD FOR MANUFACTURING THE SAME



(57) Abstract: Display of organic light-emitting diodes and method for manufacturing the same Abstract A method for depositing converter and/or absorber layers (11) on a light-emitting surface of a display-type implementation of a plurality of organic light-emitting diodes (B, G, R) for the emission of different colors comprises a step of arranging a transformation layer (10) close to the light-emitting surface and a step of local heating of the transformation layer (10), so that a material of the heated transformation layer (10) is deposited as a converter and/or absorber layer (11) on the light-emitting surface of at least one organic light-emitting diode (R).

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Display of organic light-emitting diodes and method for manufacturing the same

Description

The present invention relates to a method for manufacturing organic light-emitting diodes and in particular to manufacturing display-type light-emitting diode arrangements.

Organic light-emitting diodes (OLED) form the basis of a new class of flat panel displays. Compared to prior flat panel display concepts they offer advantages, like a large angle of view, the omitting of background lighting and the possibility to realize displays with a very low power consumption. In order to realize a full color display, the individual image elements of the display, also referred to as pixels, need to be separated into areas emitting lights of different colors.

This is possible by the fact that in every image element a separation into so-called sub-pixels with one respective emission color each takes place. Thereby, the individual colors of the display, for example red, green and blue, are then generated by spatially separated organic light-emitting diodes with different emission colors. The disadvantage of this arrangement is, however, that either the organic layers that the light-emitting diodes consist of have to be applied locally or that they have to be structured after the application. The first method can for example be realized by printing techniques with polymer OLEDs, which has for example the disadvantage, however, that the polymer systems have to be adjusted to the printing method and thereby loose some of their efficiency. Alternatively, this approach may be realized by implementing the light-emitting diodes as a member so that the layers emitting the individual colors are stacked on top of each other. The disadvantage of this arrangement is that the individual OLEDs applied on top of each other need to be transparent

and that the contact layers need to be structured by masking.

With vapor-deposited light-emitting diodes of so-called small molecules the most frequently used method is vapor deposition by shadow masks. The disadvantage here is that the masks have to be cleaned frequently and may warp by thermal defects.

A second possibility to realize the different colors according to US-5,249,870, US-9,921,936, US-6,515,428, and EP 0809420 is that the organic light-emitting diodes of the display only emit one color or white and that the color is transformed by corresponding elements. With this arrangement also a substantial problem in realizing color displays on the basis of organic light-emitting diodes is solved. Organic light-emitting diodes age during operation and loose brightness for a given current density. Due to a so-called differential ageing this ageing is different for the individual colors, so that by ageing the colors of the display are increasingly corrupted if no adjustment control may be performed.

With regard to transformation, there are again two different principles. On the one hand, the different colors for a full-color display may be realized by the fact that the organic light-emitting diode generates white light and subsequently the corresponding display colors are filtered out by filters. This arrangement has the disadvantage that during filtering the non-required other colors are respectively lost and thereby the efficiency of a display is strongly reduced.

A second solution is more advantageous, in which the organic light-emitting diode emits only one color, which is transformed into other colors by fluorescence or phosphorescence converters. Generally, this is realized by the

light-emitting diode emitting blue light by the generation of for example green and red light by conversion.

In the solutions comprising a transformation using conversion or filtering, respectively, these transforming elements need again to be structured. This may for example be performed by lithographic technologies, which are expensive, however, and may under certain circumstances not be compatible with the materials which convert or absorb, respectively.

It is the object of the present invention to provide an improved method for manufacturing a color display and a color display which is easier to produce.

This object is achieved by a method for depositing converter and/or absorber layers according to claim 1 and a display-type implementation of a plurality of organic light-emitting diodes according to claim 13.

The present invention provides a method for manufacturing a color display by depositing converter and/or absorber layers on a light-emitting surface of a display-type implementation of a plurality of organic light-emitting diodes, with the following steps:

arranging a first transformation layer close to the light-emitting surface; and

local heating of the first transformation layer, so that a material of the first transformation layer is deposited as a first converter and/or absorber layer on the light-emitting surface of at least one first organic light-emitting diode of the plurality of light-emitting diodes.

The advantage of the present invention is that a display and a method for manufacturing the same is provided, wherein for generating different emission colors converter

and/or absorber layers are provided which may be applied without the help of lithographical techniques.

The display, in particular a full color display, consists of organic light-emitting diodes onto which converter and/or absorber layers for the emission of different colors are applied. The inventive display may be obtained by a local deposition of a converter and/or absorber layer from a transformation layer which is located near the organic light-emitting diodes during deposition, wherein the local bounding is achieved by a local heating up of the transformation layer.

According to a proposed method, the converter and/or absorber layer is advantageously deposited from a second substrate, which is brought close to the substrate comprising the organic light-emitting diodes. The deposition is performed by local heating, for example by a laser. US 5,688,551 proposes such a method referred to as closed-space sublimation for the deposition of the organic light-emitting diode itself. This has, however, substantial disadvantages, as the usually relatively complex layer set-up of the organic light-emitting diodes may be realized only in a restricted way by sublimation.

According to the invention, the sublimation is accomplished from a transformation layer for a patterned deposition of the converter and/or absorber layer using a local warming of the transformation layer. This may be performed by a laser or another suitable light source. Alternatively, also the heating for example by an electrically operated source is possible.

According to one embodiment, the invention provides a display, in particular a full-color display, consisting of organic light-emitting diodes with applied converter and/or absorber layers for the emission of different colors, which is available by a local deposition of a converter and/or

absorber layer from a transformation layer, wherein during deposition the transformation layer is located near the organic light-emitting diode and the local bounding is achieved by a local heating of the transformation layer.

The transformation layer may be located on a second substrate during deposition.

According to one embodiment, the converter and/or absorber layer may be implemented in order to absorb the light emitted by the light-emitting diodes and to emit the same again with a shifted spectrum. Alternatively, the converter and/or absorber layer may be implemented as an absorbing layer in order to select individual frequency bands from the broad emission spectrum of the light-emitting diodes.

According to one embodiment, a method for depositing converter and/or absorber layers on organic light-emitting diodes for the emission of different colors in a display-type implementation, in particular with a full-color display, may be characterized in that for the deposition of a converter and/or absorber layer a transformation layer is brought close to the organic light-emitting diodes, and that the transformation layer is heated locally, so that the heated material of the transformation layer is deposited as a converter and/or absorber layer on the topmost layer of the organic light-emitting diode.

Advantageously, the method is characterized in that for the generation of image elements, which emit light of a different color, converter and/or absorber layers may be deposited next to each other from different transformation layers.

The transformation layer may be sublimed by local heating using a laser or another suitable light source. Alternatively, the transformation layer may be sublimed by an electrically operated local heat source on the substrate.

Advantageously, the transformation layer is fed to the light-emitting diodes with a substrate. Further, between the transformation layer and the substrate a second absorbing layer may be generated by a laser or another suitable light source.

In the following, preferred embodiments of the present invention are explained in more detail with reference to the accompanying drawings, in which:

Fig. 1 shows an illustration for exemplifying a first method step according to the present invention; and

Fig. 2 shows an illustration for exemplifying a second method step according to the present invention.

Fig. 1 illustrates a first method step for manufacturing a display according to the present invention. Fig. 1 hereby shows only one section of a display, which approximately corresponds to a superpixel consisting of three subpixels.

On a transparent or opaque substrate 1 an electrode 2 is applied which may be an anode or a cathode depending on the layer sequence of the organic light-emitting diode. This electrode 2 may be controlled by a passive or active electric matrix (not shown in the figures). Organic layers of one or several individually controllable OLEDs 3, which may be applied from a solution, for example of polymers, or by vapor deposition, respectively, for example of smaller molecules, follow or are arranged above the same, respectively. On those OLED layers a subsequently applied second semi-transparent electrode 4 is located which may again be an anode or a cathode. On this electrode 4 optionally a protective layer 5 may be located.

In one process step transformation layers are now applied to the OLEDs, by a second substrate 6 with a transformation layer 7 arranged on top of the same being brought close to the OLEDs, so that the transformation layer 7 is arranged opposite the protective layer 5 and the substrate is located on the side of the transformation layer 7 facing away from the protective layer 5. The distance between the protective layer 5 and the second substrate 6 may be realized by suitable spacers 8 which are arranged on the surface of the layer 4 or 5, respectively, before the same are brought close to each other.

The second substrate 6 or the transformation layer 7, respectively, is now heated locally, wherein this is performed by a light source in this embodiment, for example laser light 9, which is specifically directed to desired locations of the second substrate 6 or the transformation layer 7, respectively, and passes through the substrate 6. In this embodiment, the transformation layer 7 absorbs the laser light 9. The heating of the transformation layer 7 results in a subliming of the converter layer 11 on to the protective layer 5. Alternatively, an absorption of the laser light 9 may also be accomplished by a suitable intermediate layer (not shown in the figures) between the substrate 6 and the transformation layer 7, wherein in this case the laser beam would be directed to the same and heat up the intermediate layer. Instead of a light source a suitable heat radiator (not shown in the figures) may be used, for example an electric heat source arranged on the substrate 6.

By the local heating a first converter layer 11 (shown in Fig. 2) was deposited on a surface of the protective film 5 facing the transformation layer 7.

Fig. 2 shows the display during a second method step according to the present invention. The deposited converter layer 11 is illustrated in Fig. 2. Further, in Fig. 2 the

electrode 2 is applied to the transparent or opaque substrate 1. Subsequently the organic layers of the OLED 3 follow. Subsequently, the second semi-transparent electrode 4 is applied. On this electrode 4 the protective layer 5 follows. The OLED 3 comprises 3 sub-pixels R, G, B, comprising different colors due to different converter layers. The converter layer 11 on the second sub-pixel G causes a sub-pixel emitting green in this embodiment.

Near the protective layer now a second transformation layer 10 is located which was supplied by an additional second substrate 6a. For this purpose, the additional second substrate 6a with the second transformation layer 10 was brought close to the protective layer 5, so that the second transformation layer 10 is arranged opposite the protective layer 5. The distance may again be realized by a spacer 8.

By a local heating of the second transformation layer 10, a material of the heated second transformation layer is deposited as a second converter and/or absorber layer on a light-emitting surface of at least one second organic light-emitting diode or the second sub-pixel R, respectively, wherein the heated material of the second transformation layer is not deposited on the light-emitting surface of a third organic light-emitting diode or the third sub-pixel B, respectively, so that the second and the third organic light diodes R, B emit different colors.

According to this embodiment, the different colors of the display are now realized by the fact that a first partial area of the image element, also called pixel, remains unchanged and emits blue. A second partial area comprises the first converter layer 11, which was sublimed from the first transformation layer 7. A further third partial area comprises the second converter layer (not illustrated in the figures), which was deposited from the second transformation layer 10 according to Fig. 2.

In this embodiment, the OLED, which is formed from the layers 1 to 5 together, emits blue light. The first converter layer 11 absorbs the blue light of the OLED and emits green light. The converter layer 11 thereby causes a shifting of the frequency spectrum of the received blue light, so that red light is emitted by the converter layer 11. The second converter layer, which was produced from the transformation layer 10, absorbs blue light and emits red light. The first partial area of the display therefore emits blue light, the second partial area emits green light and the third partial area emits red light. Using the three separately controllable sub-pixels B, G, R all colors may be realized. A color display comprises a plurality of superpixels respectively constructed from three sub-pixels B, G, R.

An alternative implementation is based on the fact that the OLED emits white light and that three different transformation layers are manufactured from three different conversion layers next to each other which absorb green-blue for a red pixel, green-red for a blue pixel and red-blue for a green pixel, but do not emit own light, however. The converter layers are therefore absorber layers, which selectively absorb or let pass, respectively, individual frequency bands from the wide emission spectrum of the light-emitting diodes. Thus, also a red-green-blue arrangement of a full-color display results.

Claims

1. A method for manufacturing a color display by depositing converter and/or absorber layers on a light-emitting surface of a display-type implementation of a plurality of organic light-emitting diodes, comprising the following steps:

arranging a first transformation layer (7) close to the light-emitting surface; and

local heating of the first transformation layer, so that a material of the first transformation layer is deposited as the first converter and/or absorber layer (11) on the light-emitting surface of at least a first organic light-emitting diode (G) of the plurality of light-emitting diodes.

2. The method of claim 1, wherein the step of local heating is performed such that the heated material of the first transformation layer (7) is not deposited on the light-emitting surface of a second organic light-emitting diode (R) of the plurality of light-emitting diodes, so that the first organic light-emitting diode (G) and the second organic light-emitting diode (R) emit different colors.

3. The method of claim 2, further comprising:

arranging a second transformation layer (10) close to the light-emitting surface; and

local heating of the second transformation layer, so that a material of the second transformation layer is deposited as a second converter and/or absorber layer on the light-emitting surface of at least a third organic light-emitting diode (R) of the plurality of light-emitting diodes.

4. The method of claim 3, wherein the local heating of the second transformation layer is performed such that the second is equal to the third organic light-emitting diode.

5. The method of claim 3 or 4, wherein the step of local heating is performed such that the heated material of the second transformation layer (10) is not deposited on the light-emitting surface of a forth organic light-emitting diode (B) of the plurality of light-emitting diodes, so that the first organic light-emitting diode (G), the third organic light-emitting diode (R), and the forth organic light-emitting diode (B) emit different colors.

6. The method of one of claims 1 to 5, wherein the step of arranging the first transformation layer is implemented such that after the arrangement the first transformation layer (7) is located on a first substrate (6) during deposition.

7. The method of one of claims 3 to 6, wherein the step of arranging the second transformation layer is performed such that the second transformation layer (10) is located on a second substrate (6a) during deposition.

8. The method of one of claims 1 to 7, wherein the first converter and/or absorber layer (11) is implemented in order to absorb the emitted light from the first light-emitting diode (G) and emit the same again with a shifted spectrum.

9. The method of one of claims 1 to 7, wherein the first converter and/or absorber layer (11) is implemented in order to select individual frequency bands from the

wide emission spectrum of the light-emitting diodes and to block the rest of the frequencies.

10. The method of one of claims 1 to 9, wherein the step of heating comprises subliming the first transformation layer (7) by local heating using a light source.

11. The method of one of claims 6 to 8, wherein the step of heating comprises the subliming of the first transformation layer (7) by an electrically operated local heat source on the first substrate (6).

12. The method of one of claims 6 to 10, wherein the step of heating comprises the warming up of an absorbing layer arranged between the first transformation layer (7) and the first substrate (6) by a suitable light source.

13. A color display comprising a display-type implementation of a plurality of organic light-emitting diodes and converter and/or absorber layers deposited on a light-emitting surface of a display-type implementation, which is obtained by a local heating of a first transformation layer (7) arranged close to the light-emitting surface, so that a material of the heated first transformation layer is deposited as the first converter and/or absorber layer (11) on the light-emitting surface of at least one first organic light-emitting diode (G).

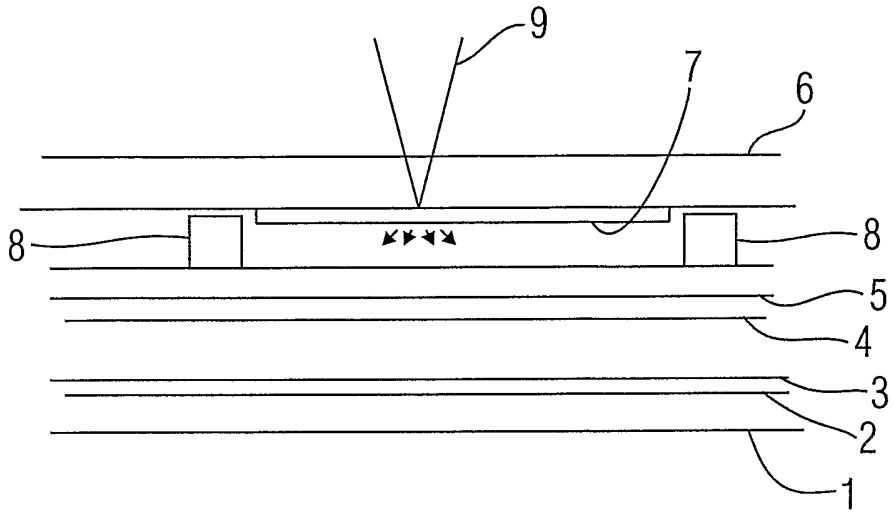


FIG. 1

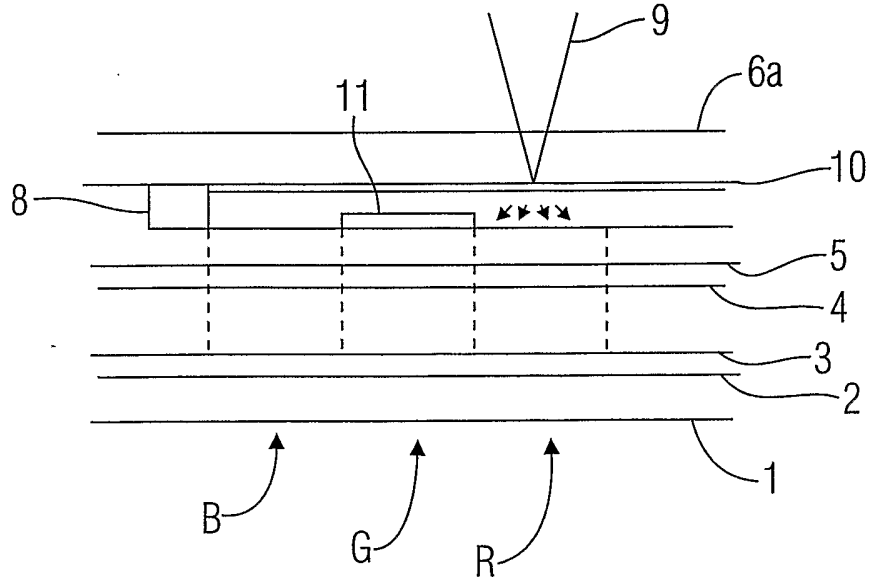


FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2004/007907

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L51/40

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)
IPC 7 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, INSPEC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 6 221 553 B1 (WOLK MARTIN B ET AL) 24 April 2001 (2001-04-24) the whole document column 5, line 7 - column 6, line 18 column 10, line 35 - column 14, line 45 figure 4	1-12
Y	US 6 358 664 B1 (LE HA T ET AL) 19 March 2002 (2002-03-19) column 1, line 1 - line 15 column 11, line 9 - column 15, line 26 figures 1,2	1-12
X Y	US 2001/043043 A1 (AOYAMA MEGUMI ET AL) 22 November 2001 (2001-11-22) the whole document figures 3,4	13 1-3,5-12

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

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 November 2004	02/12/2004

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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