

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
4 December 2008 (04.12.2008)

PCT

(10) International Publication Number
WO 2008/147124 A1

(51) International Patent Classification:
H05B 33/02 (2006.01)

(21) International Application Number:
PCT/KR2008/003021

(22) International Filing Date: 29 May 2008 (29.05.2008)

(25) Filing Language: Korean

(26) Publication Language: English

(30) Priority Data:
10-2007-0052213 29 May 2007 (29.05.2007) KR

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(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, 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, 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, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

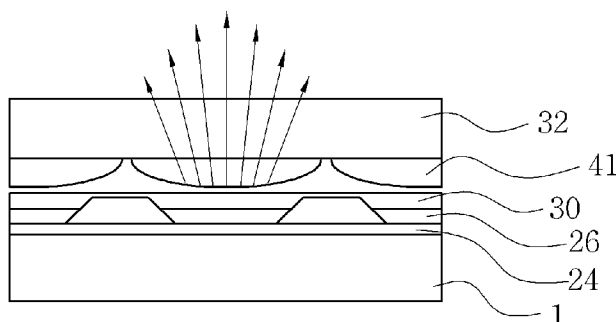
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT,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

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

(54) Title: ORGANIC ELECTROLUMINESCENT DEVICE

[Fig. 4]



(57) Abstract: An organic electroluminescent device of a top emission type includes a lower substrate, an organic electroluminescent diode provided over the lower substrate and emitting light by an applied driving current, and an encapsulation substrate provided over the organic electroluminescent diode and encapsulating the organic electroluminescent diode, wherein one or more micro lenses are provided under the encapsulation substrate for each sub-pixel so as to change an orientation angle of light emitted upward from the organic electroluminescent diode. The micro lens has a convex or concave shape facing the organic electroluminescent diode. The micro lens has a spheric or aspheric lens surface. The micro lens has a rectangular outer circumference

corresponding to the sub-pixel. The plurality of the micro lenses is provided for each sub-pixel along a long-axis of the sub-pixel. The micro lens is a refraction lens including a Fresnel lens or a diffraction lens.

Description

ORGANIC ELECTROLUMINESCENT DEVICE

Technical Field

- [1] The present invention relates to an organic electroluminescent device, and more particularly, to a top emission type.

Background Art

- [2] Recently, because of the light weight and low power consumption, liquid crystal displays (LCDs) have been most widely used as flat panel displays (FPDs).
- [3] However, since the LCDs are not a self light emitting type and has technical limitations in increasing a contrast, a viewing angle, a image size, and the like, actively exerted have been efforts to develop a new FPD which can overcome such problems.
- [4] Since an organic electroluminescent device, one of the new FPDs, is a self-emitting type, it does not need a backlight and thus it can be made lighter and thinner and be advantageous in power consumption. Its viewing angle, its contrast, and the like are excellent as compared to the LCDs. Furthermore, since it is drivable under direct current and low voltage, has a rapid response speed, and is composed of solid material, it is resistant to external shocks, and has a wide usable temperature range and a low manufacturing cost.
- [5] In particular, since equipment required for a manufacturing process of the organic electroluminescent device unlike the LCD or a plasma display panel (PDP) includes only deposition and encapsulation apparatuses, the manufacturing process may be carried out very simply.
- [6] The organic electroluminescent device is classified into a passive matrix (PM) type and an active matrix (AM) type.
- [7] The PM type organic electroluminescent device is not provided with a thin film transistor (TFT), a separate switching device. In the PM type organic electroluminescent device, scanning lines and signal lines are crossed each other to form a matrix. The scanning lines are sequentially driven with time in order to drive respective sub-pixels. In order to obtain needed average luminance, it has to have instant luminance corresponding to the average luminance times the number of lines.
- [8] Conversely, the AM type organic electroluminescent device has the TFTs, the switching devices, each of which is located in each sub-pixel. Lower electrodes connected with the TFTs are turned ON/OFF independently of one another, and an upper electrode serves as a common electrode.
- [9] Furthermore, since, in the AM type organic electroluminescent device, voltage applied to the sub-pixels is charged into a storage capacitor C_{st} and thus, power can be

applied until a next frame signal is applied, the AM type organic electroluminescent device can be continuously driven during a single picture irrespective of the number of the scanning lines. Thus, the AM type ORGANIC ELECTROLUMINESCENT DEVICE has the same luminance even under low current and thus can achieve low power consumption, high definition, and large image size.

[10] FIG. 1 is a view illustrating a basic pixel structure of a conventional active matrix type organic electroluminescent device.

[11] As shown in the figure, scanning lines are arranged in a first direction, and a signal line and a power supply line are spaced apart from each other and are arranged in a second direction intersecting the first direction, thereby defining a sub-pixel region.

[12] A switching TFT, an addressing element, is arranged at an intersection point of the scanning lines and the signal line. A storage capacitor Cst is so arranged that it is connected with the switching TFT and the power supply line. A driving TFT, a current source element, is so arranged that it is connected with the storage capacitor Cst and the power supply line. An organic electroluminescent diode is so arranged that it is connected with the driving TFT.

[13] When a forward current is supplied to an organic electroluminescent material by an anode electrode providing holes and a cathode electrode providing electrons, the electrons move across a P-N junction and then recombines with holes. This lowers energy level to emit light corresponding to such a difference of energy.

[14] The switching TFT serves to control voltage and store a current source.

[15] The organic electroluminescent device is classified into a top emission type and a bottom emission type according to an advancing direction of light emitted from the organic electroluminescent diode.

[16] FIG. 2 is a cross-sectional view illustrating a conventional top emission type organic electroluminescent device, centering on a light-emitting region, which is defined as a region through which emitted light is transmitted.

[17] As illustrated in the figure, in the light-emitting region II, a thin film transistor T including a gate electrode 12, a semiconductor layer 16, and source and drain electrodes 18 and 20 is formed on a lower substrate 1. An organic electroluminescent diode E is connected with the thin film transistor T.

[18] The organic electroluminescent diode E includes an upper electrode 30, a lower electrode 24, and an organic electroluminescent layer 26 interposed therebetween.

[19] Here, the organic electroluminescent layer 26 is provided for each sub-pixel. The organic electroluminescent layers 26 are apart from one another by a dielectric layer 28 which is located on the lower electrode 24. In case of the top emission type, the organic electroluminescent layer 26 is formed even over the thin film transistor T.

[20] Further, which electrode of the upper and lower electrodes 30 and 24 serves as an

anode or a cathode is determined according to carriers supplied from the thin film transistor T.

[21] That is, in case that the diode is connected with an n-type thin film transistor in which the carrier is the electron, the lower electrode 24 and the upper electrode 30 serve as a cathode and an anode, respectively, and in case that the diode is connected with a p-type thin film transistor, vice versa.

[22] An encapsulation substrate 32 is typically made of a glass or quartz substrate.

[23] In the top emission type organic electroluminescent device, the upper electrode is composed of light transmitting material, e.g. Indium Tin Oxide (ITO) or metallic material containing the ITO, and the lower electrode is composed of high reflective metal, such as Au, Ag, Pt, or Al.

[24] According to a display device with the organic electroluminescent device, an optical characteristic required for the organic electroluminescent device is different. For example, display devices such as TVs requires the organic electroluminescent device to have wide viewing angle, whereas display devices such as mobile phones and notebook monitors requires the organic electroluminescent device to have high front luminance rather than the wide viewing angle.

[25] However, the conventional organic electroluminescent devices have their own orientation angle. Generally, the orientation angle ($2\theta/2$) of the organic electroluminescent device is approximately 120 degrees. Thus, there is a technical limit in meeting diverse requirements of the optical characteristics, such as the high front luminance or the wide viewing angle, which respective display devices require.

Disclosure of Invention

Technical Problem

[26] Accordingly, the present invention has been made to solve the above problem occurring in the prior art, and an object of the present invention is to provide an organic electroluminescent device capable of meeting the requirements of the optical characteristics, such as the high front luminance or the wide viewing angle, which respective display devices require, and eventually providing a high quality display device.

Technical Solution

[27] In order to achieve the above object, according to one aspect of the present invention, there is provided a top emission type organic electroluminescent device including: a lower substrate; organic electroluminescent diodes provided over the lower substrate and emitting light by an applied driving current; and an encapsulation substrate provided over the organic electroluminescent diodes and encapsulating the organic electroluminescent diodes, wherein one or more micro lenses are provided under the en-

capsulation substrate for each sub-pixel to change an orientation angle of light emitted upward from the organic electroluminescent diode.

- [28] Preferably, the micro lens may have a convex or concave shape facing the organic electroluminescent diode.
- [29] Preferably, the micro lens may have a spheric or aspheric lens surface.
- [30] Preferably, the micro lens may have a rectangular outer circumference corresponding to the sub-pixel.
- [31] Preferably, the plurality of the micro lenses may be provided for each sub-pixel along a long-axis (a major axis) of the sub-pixel.
- [32] Preferably, the micro lens may be a refraction lens including a Fresnel lens or a diffraction lens.
- [33] Preferably, the micro lens may be made of ultraviolet-imprintable or heat-imprintable material.
- [34] Preferably, the micro lens may be formed by embossing or intaglioing the lower surface of the encapsulation substrate.
- [35] Preferably, the micro lenses may have different shapes according to sub-pixels of red, green, and blue to compensate a difference in wavelengths of a red ray, a green ray, and a blue ray.
- [36] Preferably, the organic electroluminescent device may further include a thin film transistor between the lower substrate and the organic electroluminescent diode.
- [37] Preferably, the organic electroluminescent diode may include an opaque lower electrode provided over the lower substrate, an organic electroluminescent layer provided over the lower electrode, and a transparent upper electrode provided over the organic electroluminescent layer.

Advantageous Effects

- [38] According to the present invention, the organic electroluminescent device is able to meet the requirements of the optical characteristics, such as the high front luminance or the wide viewing angle, which respective display devices require, and eventually providing a high quality display device.

Brief Description of the Drawings

- [39] The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description given with reference to the accompanying drawings, in which:
- [40] FIG. 1 is a view illustrating a basic pixel structure of an active matrix type organic electroluminescent device;
- [41] FIG. 2 is a cross-sectional view illustrating a conventional top emission type organic electroluminescent device;

- [42] FIGS. 3 to 5 are views explaining the principal concept of the present invention, wherein FIG. 3 is a concept view of a conventional organic electroluminescent device, FIG. 4 is a concept view of an organic electroluminescent device according to a first embodiment of the invention, and FIG. 5 is a concept view of an organic electroluminescent device according to a second embodiment of the invention;
- [43] FIG. 6 is a view illustrating an arrangement of micro lenses according to a third embodiment of the invention;
- [44] FIG. 7 is a view illustrating an arrangement of micro lenses according to a fourth embodiment of the invention;
- [45] FIG. 8 is a view illustrating an arrangement of sub-pixels of organic electroluminescent diodes;
- [46] FIG. 9 shows the luminance of the organic electroluminescent device having the arrangement of the micro lenses shown in FIG. 6;
- [47] FIG. 10 shows the luminance of the organic electroluminescent device having the arrangement of the micro lenses shown in FIG. 7; and
- [48] FIG. 11 is a view illustrating a method of manufacturing a micro lens according to a fifth embodiment of the invention.

Mode for the Invention

- [49] Reference will now be made in greater detail to a preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings.
- [50] FIGS. 3 to 5 are views explaining the principal concept of the present invention, wherein FIG. 3 is a concept view of a conventional organic electroluminescent device, FIG. 4 is a concept view of an organic electroluminescent device according to a first embodiment of the invention, and FIG. 5 is a concept view of an organic electroluminescent device according to a second embodiment of the invention.
- [51] As illustrated in the figures, the organic electroluminescent device of the present invention includes a lower substrate 1, organic electroluminescent diodes, an encapsulation substrate 32, and micro lenses 41 and 43.
- [52] Although not illustrated in the figures, the active matrix type organic electroluminescent device further includes a thin film transistor between the lower substrate 1 and the organic electroluminescent diode.
- [53] The electroluminescent diodes are provided over the lower substrate 1, and emit light by an applied driving current. The organic electroluminescent diode includes a lower electrode 24, an organic electroluminescent layer 26, and an upper electrode 30.
- [54] The lower electrode 24 is provided over the lower substrate 1 and is opaque in order to prevent a loss of light in downward direction. The organic electroluminescent layer 26 is provided over the lower electrode 24. The organic electroluminescent layer 26

includes an injection layer, a transfer layer, and a light-emission material layer. The upper electrode 30 is provided over the organic electroluminescent layer 26 and is transparent, allowing light to be emitted upward.

[55] The encapsulation substrate 32 is provided over the organic electroluminescent diode. The encapsulation substrate 32 is sealed up together with the lower substrate 1 to encapsulate the organic electroluminescent diode.

[56] A space is formed between the organic electroluminescent diode and the encapsulation substrate 32. Micro lenses 41 and 43 are provided in the space. The micro lenses 41 and 43 may be formed by directly embossing or intaglioing a lower surface of the encapsulation substrate 32. However, in view of mass production and a cost, as illustrated in FIG. 11, the micro lenses are formed by imprinting polymer on the lower surface of the encapsulation substrate.

[57] In case that the micro lenses 41 and 43 are formed over the encapsulation substrate 32, since a thickness of the encapsulation substrate 32 is much larger than the size of the sub-pixel, light emitted from the sub-pixel does not correspond to the micro lenses 41 and 43 directly above the sub-pixel. This degrades the definition of an image. Thus, in the present invention, the micro lenses 41 and 43 are formed under the encapsulation substrate 32.

[58] The micro lenses 41 and 43 changes an orientation angle of light emitted upward from the organic electroluminescent diode. For example, in case of a display device such as mobile phones and computer monitors, the organic electroluminescent device as illustrated in FIG. 4 is properly adopted. The micro lens 41 illustrated in FIG. 4 has a convex shape facing the organic electroluminescent diode. Thus, the micro lens 41 reduces the orientation angle of light emitted from the organic electroluminescent diode to thereby increase the front luminance. A simulation proved that the front luminance was improved by 20% to 60%.

[59] Conversely, in case of a display device such as a TV, the organic electroluminescent device as illustrated in FIG. 5 is properly adopted. The micro lens 43 shown in FIG. 5 has a concave shape facing the organic electroluminescent diode. Thus, the micro lens 43 increases the orientation angle of light emitted from the organic electroluminescent diode, allowing the display device to have a wide viewing angle.

[60] FIG. 6 is a view illustrating an arrangement of micro lenses 41 according to a third embodiment of the invention, and FIG. 7 is a view illustrating an arrangement of micro lenses 41 according to a fourth embodiment of the invention.

[61] FIGS. 6 and 7 illustrate a lower surface of the encapsulation substrate 32 on which micro lenses are formed corresponding to 15x5 sub-pixels (5x5 pixels).

[62] One or more micro lenses 41 are provided for each sub-pixel of red, green, and blue. The micro lens 41 has a spheric or aspheric lens surface. The micro lens 41 may have a

rectangular outer circumference corresponding to the sub-pixel.

- [63] FIG. 6 shows an embodiment in which one micro lens 41 is provided for each sub-pixel (three micro lenses 41 for each pixel), and the spheric or aspheric lens surface has a rectangular outer circumference to match the shape of the sub-pixel. Preferably, the micro lens 41 has the same center as the sub-pixel.
- [64] The plurality of micro lenses 41 can be provided for each sub-pixel. FIG. 7 shows an embodiment in which three micro lenses 41 are provided for each sub-pixel (nine micro lenses 41 for each pixel), and the spheric or aspheric lens surface of each micro lens 41 has a rectangular outer circumference. The plurality of micro lenses 41 is arranged along a long axis of the sub-pixel.
- [65] As compared to the structure shown in FIG. 6, the structure in FIG. 7 enables the orientation angle to be efficiently controlled along the long axis of the sub-pixel, contributing to improvement in front luminance and a viewing angle. That is, when only one micro lens 41 or 43 is provided along the long axis for each sub-pixel, a radius of curvature increases, which deteriorate the performance of light-focusing (in case of the micro lens 41 in FIG. 3) or the performance of light-diffusing (in case of the micro lens 43 in FIG. 5). Thus, it is more preferable that the plurality of micro lenses 41 and 43 is arranged.
- [66] Further, the structure shown in FIG. 7 also helps the organic electro-luminescent device to be made thinner.
- [67] The micro lens 41 may have diverse structures other than the structures as shown above, and may be a refraction lens including a Fresnel lens or a diffraction lens.
- [68] The micro lens 41 may have different shapes according to sub-pixels of red, green, and blue. This is because the refraction or diffraction degree of each color light varies due to a difference in wavelengths of a red ray, a green ray, and a blue ray. The micro lenses with different shapes according to sub-pixels compensate for the difference.
- [69] FIG. 8 is a view illustrating an arrangement of sub-pixels of organic electroluminescent diodes, FIG. 9 shows the luminance of the organic electroluminescent device having the arrangement of the micro lenses 41 shown in FIG. 6, and FIG. 10 shows the luminance of the organic electroluminescent device having the arrangement of the micro lenses 41 shown in FIG. 7.
- [70] FIG. 8 shows 15x5 sub-pixels (5x5 pixels), and FIGS. 9 and 10 shows 6x2 sub-pixels (2x2 pixels).
- [71] As illustrated, in FIG. 9, each sub-pixel forms one distinguishable luminance area, whereas in FIG. 10, each sub-pixel forms three distinguishable luminance areas.
- [72] FIG. 11 is a view illustrating a method of manufacturing a micro lens 41 according to a fifth embodiment of the invention.
- [73] The micro lens 41 can be formed by various methods using a MEMS process. FIG.

11 shows a method of forming the micro lens 41 using ultraviolet (UV)-imprinting or heat-imprinting.

[74] As illustrated, UV- or heat-imprintable material is applied onto the encapsulation substrate 32, and the material is exposed to UV or heat while being pressed with a mold 51, thereby forming the micro lens 41.

[75] Reference numbers 53 and 55 denote a mold jig and a ram, respectively.

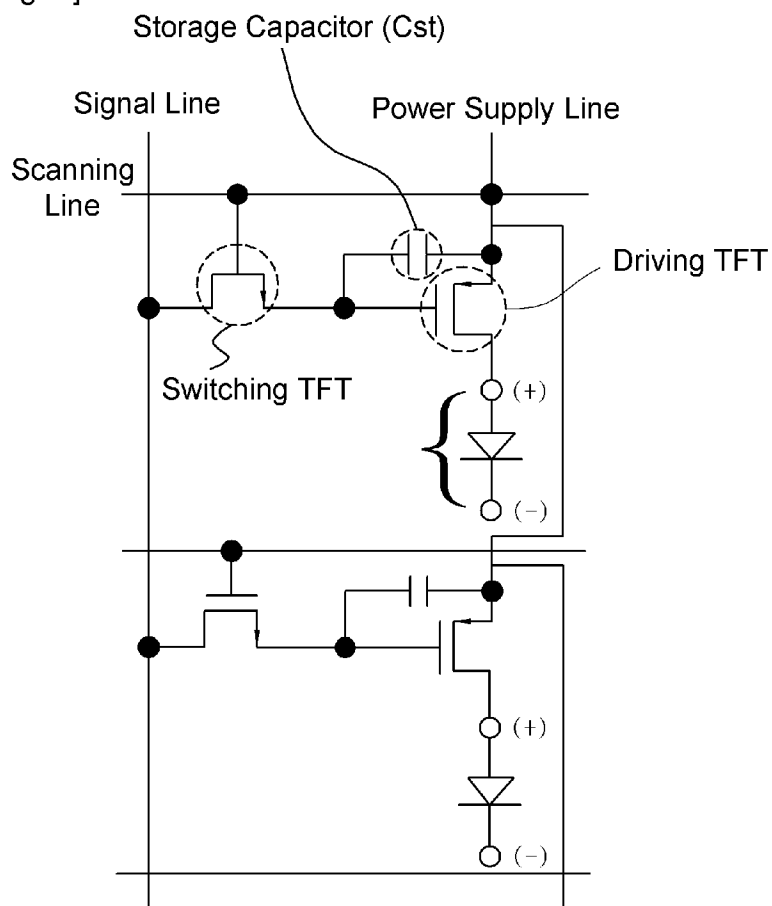
[76] In the drawings and specification, typical exemplary embodiments of the invention have been disclosed, and although specific terms are employed, they are used in a generic and descriptive sense only and are not for the purposes of limitation, the scope of the invention being set forth in the following claims.

Claims

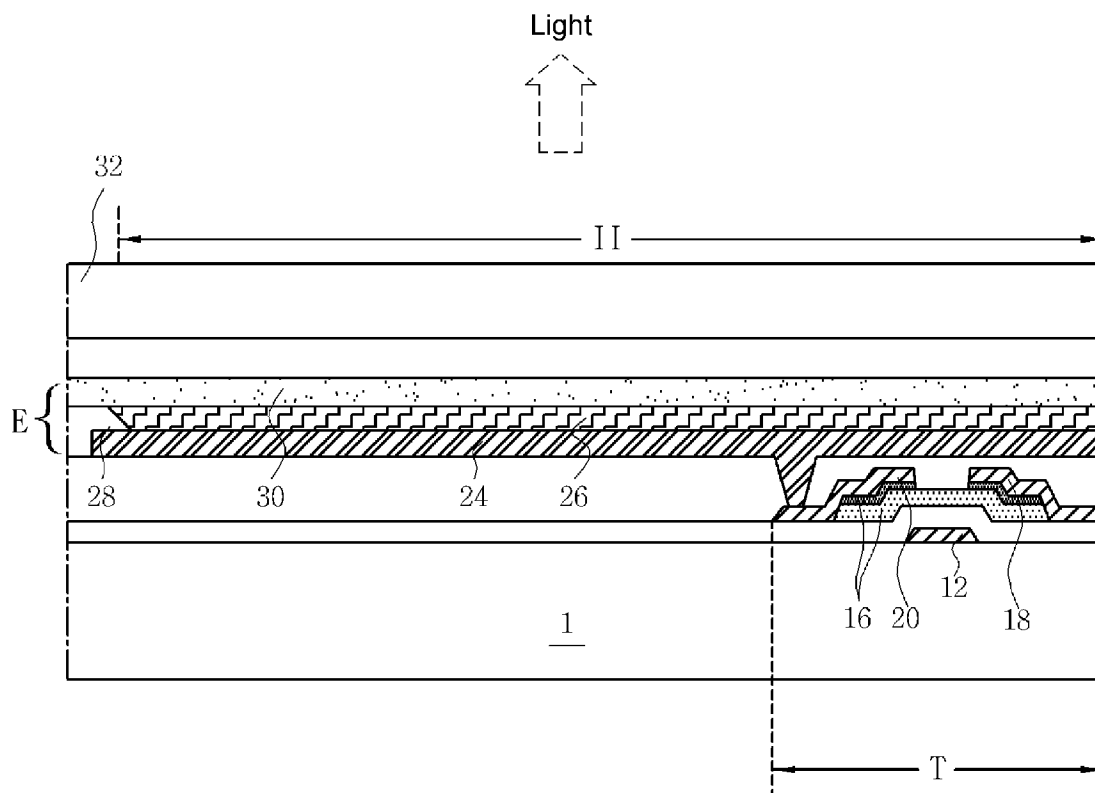
- [1] An organic electroluminescent device of a top emission type comprising:
a lower substrate;
organic electroluminescent diodes provided over the lower substrate and emitting light by an applied driving current; and
an encapsulation substrate provided over the organic electroluminescent diodes and encapsulating the organic electroluminescent diodes,
wherein one or more micro lenses are provided under the encapsulation substrate for each sub-pixel.
- [2] The organic electroluminescent device according to claim 1, wherein the micro lens changes an orientation angle of light emitted upward from the organic electroluminescent diode.
- [3] The organic electroluminescent device according to claim 1, wherein the micro lens has a convex or concave shape facing the organic electroluminescent diode.
- [4] The organic electroluminescent device according to claim 1, wherein the micro lens has a spheric or aspheric lens surface.
- [5] The organic electroluminescent device according to claim 1, wherein the micro lens has a rectangular outer circumference corresponding to the sub-pixel.
- [6] The organic electroluminescent device according to claim 1, wherein the plurality of the micro lenses is provided for each sub-pixel along a long-axis of the sub-pixel.
- [7] The organic electroluminescent device according to claim 1, wherein the micro lens is a refraction lens including a Fresnel lens or a diffraction lens.
- [8] The organic electroluminescent device according to claim 1, wherein the micro lens is made of ultraviolet-imprintable or heat-imprintable material.
- [9] The organic electroluminescent device according to claim 1, wherein the micro lens is formed by embossing or intaglioing the lower surface of the encapsulation substrate.
- [10] The organic electroluminescent device according to claim 1, wherein the micro lenses have different shapes according to sub-pixels of red, green, and blue to compensate a difference in wavelengths of a red ray, a green ray, and a blue ray.
- [11] The organic electroluminescent device according to claim 1, comprising a thin film transistor between the lower substrate and the organic electroluminescent diode.
- [12] The organic electroluminescent device according to claim 1, wherein the organic electroluminescent diode includes an opaque lower electrode provided over the lower substrate, an organic electroluminescent layer provided over the lower

electrode, and a transparent upper electrode provided over the organic electroluminescent layer.

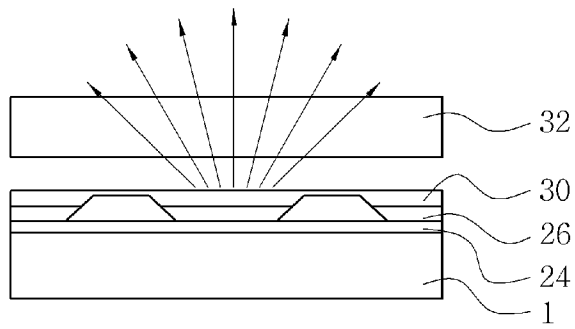
[Fig. 1]



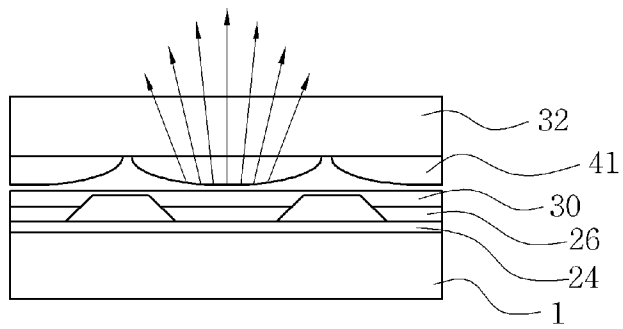
[Fig. 2]



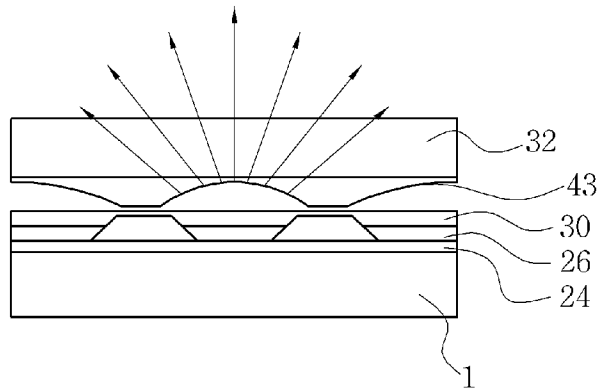
[Fig. 3]



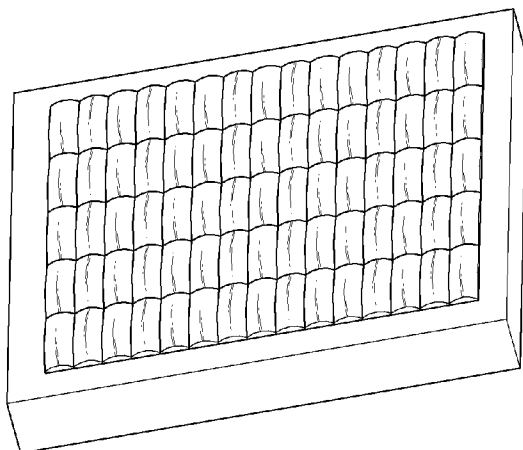
[Fig. 4]



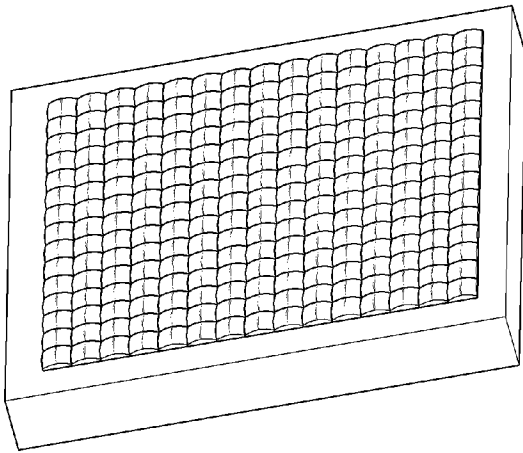
[Fig. 5]



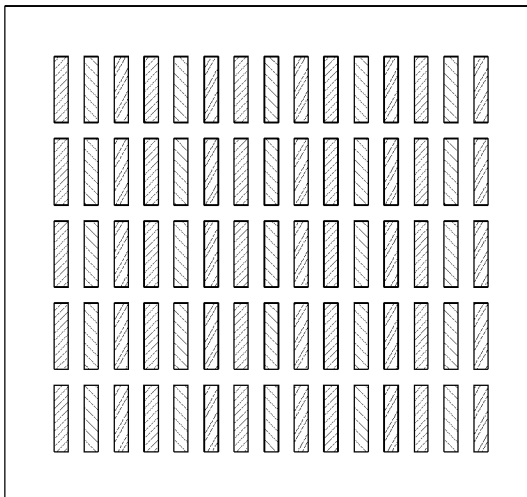
[Fig. 6]



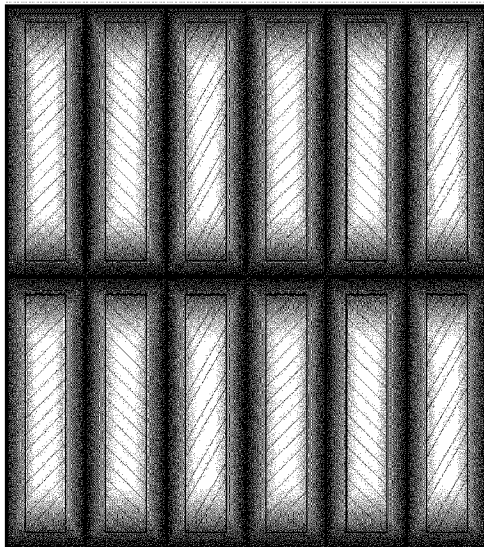
[Fig. 7]



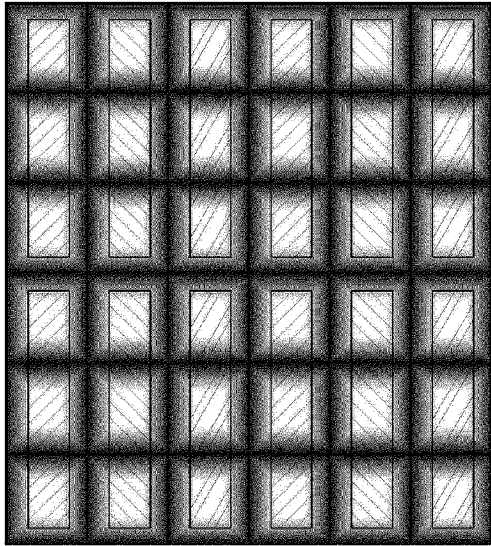
[Fig. 8]



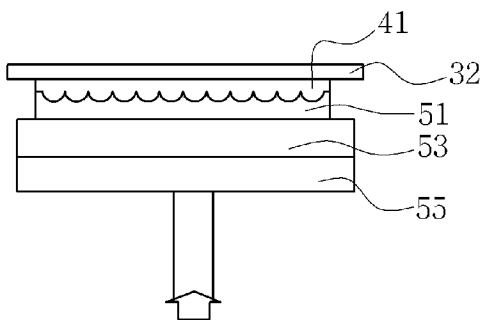
[Fig. 9]



[Fig. 10]



[Fig. 11]



A. CLASSIFICATION OF SUBJECT MATTER***H05B 33/02(2006.01)i***

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 8 H05B, H03K, G09G

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

Korea Utility Models and applications for utility models since 1975

Japanese Utility Models and applications for utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKIPASS(KIPO internal) & Keywords: "lens", "encapsulation", and "organic electroluminescent"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2006-0114086 A (SAMSUNG SDI CO., LTD.) 06 NOV 2006 See Abstract; Fig. 5 and its corresponding explanations	1-12
A	KR 10-2005-0112317 A (SAMSUNG SDI CO., LTD.) 30 NOV 2005 See Abstract; Fig. 1 and its corresponding explanatons	1-12
A	JP 11-074072 A (SHARP CORP) 16 MAR 1996 See Abstract; Fig. 1 and its corresponding explanatons	1-12
A	JP 2004-127662 A (SONY CORP) 22 APR 2004 See Abstract; Fig. 3 and its corresponding explanatons	1-12



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

29 OCTOBER 2008 (29.10.2008)

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Information on patent family members

International application No.

PCT/KR2008/003021

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