(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 473 772 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
03.11.2004 Bulletin 2004/45

(51) Int Cl.[7]: **H01L 27/00**

(21) Application number: **04076186.8**

(22) Date of filing: **19.04.2004**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL HR LT LV MK

(30) Priority: **30.04.2003 US 426299**

(71) Applicant: **EASTMAN KODAK COMPANY**
Rochester, New York 14650 (US)

(72) Inventors:
- **The inventors have agreed to waive their entitlement to designation.**

(74) Representative: **Haile, Helen Cynthia**
Kodak Limited
Patent Department, W92-3A,
Headstone Drive
Harrow, Middlesex HA1 4TY (GB)

(54) **A color oled display with improved power efficiency**

(57) A color OLED display includes an array of light emitting OLED pixels, each pixel having three or more gamut elements for emitting different colors of light specifying a gamut and at least one additional element for emitting a color of light within the gamut and wherein the power efficiency of the additional element is higher than the power efficiency of at least one of the three or more gamut elements; wherein all of the gamut elements for each color in the display are arranged in a first direction in a line such that no differently colored gamut element is in the line; wherein the colored gamut elements are arranged in a second direction orthogonal to the first direction in a line such that the colors of the gamut elements alternate in that line; and wherein the additional elements are arranged in lines in both the first and second directions.

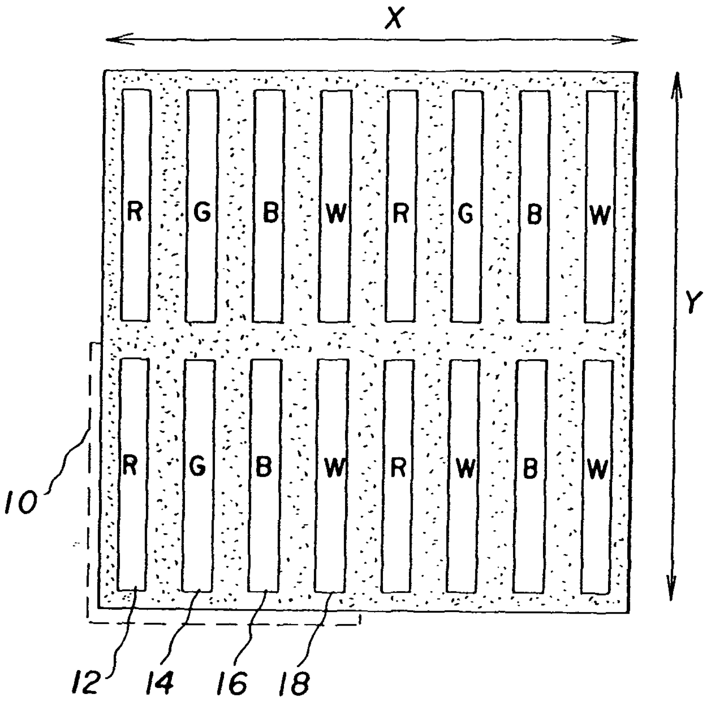


FIG. 1

EP 1 473 772 A2

Description

[0001] The present invention relates to OLED color displays and, more particularly, to arrangements of light emitting elements in such OLED color displays.

[0002] US Patent Application No. 2002/0186214A1 by Siwinski et al., published December 12, 2002, shows a method for saving power in an organic light emitting diode (OLED) display having pixels comprised of red, green, blue and white light emitting elements. The white light emitting elements are more efficient than the other colored light emitting elements and are employed to reduce the power requirements of the display.

[0003] While power efficiency is always desirable, it is particularly desirable in portable applications because an inefficient display limits the time the device can be used before the power source is recharged. In fact, for certain applications the rate of power consumption may be more important than any other display characteristic with the exception of visibility. Referring to Fig. 2, an arrangement of four pixels 10 having red 12, green 14, blue 16 and white 18 light emitting elements as taught by Siwinski is shown. The light emitting elements in each pixel are arranged in a two by two array.

[0004] Widely used text rendering software such as **Microsoft ClearType™** relies upon displays in which the colored elements of the display are arranged to form vertical stripes. Such arrangements are known in LCD displays that have pixels comprised of red, green, and blue light emitting elements. An example of such an arrangement is shown in Fig. 3, however this arrangement does not provide the power savings of the display device taught by Siwinski.

[0005] There is a need, therefore, for an improved full-color flat-panel OLED display having improved power efficiency while maintaining full-color reproduction and compatibility with a stripe-pattern arrangement.

[0006] The need is met by providing a color OLED display that includes an array of light emitting OLED pixels, each pixel having three or more gamut elements for emitting different colors of light specifying a gamut and at least one additional element for emitting a color of light within the gamut and wherein the power efficiency of the additional element is higher than the power efficiency of at least one of the three or more gamut elements; wherein all of the gamut elements for each color in the display are arranged in a first direction in a line such that no differently colored gamut element is in the line; wherein the colored gamut elements are arranged in a second direction orthogonal to the first direction in a line such that the colors of the gamut elements alternate in that line; and wherein the additional elements are arranged in lines in both the first and second directions.

[0007] The advantages of this invention are a color display device with improved power efficiency and compatibility with stripe pattern arrangements.

Fig. 1 is a schematic diagram of a portion of an OLED display having light emitting elements arranged according to one embodiment of the present invention;

Fig. 2 is a schematic diagram of a portion of an OLED display having light emitting elements arranged according to the prior art;

Fig. 3 is a schematic diagram of a portion of an OLED display having light emitting elements arranged according to the prior art;

Fig. 4 is a side view of a portion of a top-emitting OLED display according to one embodiment of the present invention;

Fig. 5 is a side view of a portion of a bottom-emitting OLED display according to one embodiment of the present invention;

Fig. 6 is a schematic diagram of a portion of an OLED display having light emitting elements arranged according to an alternative embodiment of the present invention;

Fig. 7 is a schematic diagram of a portion of an OLED display having light emitting elements arranged according to another alternative embodiment of the present invention;

Fig. 8 is a schematic diagram of a portion of an OLED display having light emitting elements arranged according to another alternative embodiment of the present invention;

Fig. 9 is a schematic diagram of a portion of an OLED display having light emitting elements arranged according to another alternative embodiment of the present invention;

Fig. 10 is a side view of a portion of a top-emitting OLED display according to another embodiment of the present invention;

Fig. 11 is a circuit layout diagram of a portion of the pixel area of an OLED display of the type shown in Fig. 7;

Fig. 12 is a detailed layout diagram of a portion of the pixel area of an OLED display shown in Fig. 11;

Fig. 13 is a cross sectional diagram of one light emitting element in an OLED display;

Fig. 14 is an alternative circuit layout diagram of a portion of the pixel area of an OLED display of the type shown in Fig. 7;

Fig. 15 is a more detailed layout diagram of a portion of the pixel area of an OLED display shown in Fig. 14;

Fig. 16 is another alternative circuit layout diagram of a portion of the pixel area of an OLED display of the type shown in Fig. 7;

Fig. 17 is a more detailed layout diagram of a portion of the pixel area of an OLED display shown in Fig. 16;

Fig. 18 is another alternative layout diagram of a portion of the pixel area of an OLED display of the type shown in Fig. 8; and

Fig. 19 is a schematic side view of an OLED light emitting element according to the prior art.

[0008] Referring to Fig. 1, an OLED display according to the present invention includes an array of light emitting OLED pixels **10**, each pixel having three or more gamut elements such as red **12**, green **14**, blue **16** light emitting elements for emitting different colors of light specifying a gamut and at least one additional element such as white light emitting element **18** for emitting a color of light within the gamut. The power efficiency of the additional element is higher than the power efficiency of the gamut elements so that by driving the additional element in place of the gamut elements, the power consumption of the display may reduced. All of the gamut elements for each color in the display are arranged in a first direction Y in a line such that no differently colored gamut element is in the line. The colored gamut elements are arranged in a second direction X orthogonal to the first direction in a line such that the colors of the gamut elements alternate in that line. This arrangement of light emitting elements is compatible with text rendering software that requires stripe-pattern displays. The light emitting elements in the pixels are all individually addressable using conventional means.

[0009] According to the present invention, luminance that would conventionally be produced by a combination of lower power efficiency gamut elements can instead be produced by the higher power efficiency additional elements. Thus, any color that can be reproduced using the additional elements will be more efficient than an equivalent reproduction using the gamut elements. A suitable transformation function may be provided by a signal processor that converts a standard color image signal to a power saving image signal that is employed to drive the display of the present invention.

[0010] The present invention can be employed in most OLED device configurations that include four or more OLEDs per pixel. These include very unsophisticated structures comprising a separate anode and cathode per OLED to more sophisticated devices, such as passive matrix displays having orthogonal arrays of anodes and cathodes to form pixels, and active-matrix displays where each pixel is controlled independently, for example, with a thin film transistor (TFT).

[0011] Referring to Fig. 4, a top-emitting OLED display having a plurality of light emitting elements includes a single layer of white light emitting material 30 formed on a substrate **20**. A plurality of electrodes **22, 24, 26**, and **28** separated by insulators **29** define the light emitting elements **12, 14, 16** and **18** (see Fig. 1). A second transparent electrode 32 is formed on the white-light emitting organic material **30**. Red **42**, green **44**, blue **46** color filters are provided over the electrodes **22**, **24**, and **26** respectively so that when white light is emitted from the organic layer **30**, red light **52** is emitted above electrode **22**, green light **54** is above electrode **24**, and blue light **56** is above electrode 26. Unfiltered, white light **58** is emitted above electrode **28**. A transparent encapsulating cover (not shown) is provided over the device. Alternative arrangements of the electrodes **22-28** and color filters **42-46** may be provided as described below. Moreover, an additional filter (not shown) may be supplied above the white emitter to adjust the white point of the light emitted from the additional light emitting elements.

[0012] Referring to Fig. 5, in a bottom-emitting arrangement, light is emitted through the substrate **20**. In this arrangement, the second electrode **32** need not be transparent while the first electrodes **22, 24, 26**, and **28** are transparent. The color filters **42, 44, 46,** and a white point adjusting filter **48** are formed on the substrate **20** prior to forming the light emitting elements.

[0013] The present invention provides compatibility with color stripe patterns preferred for rendering text. In the simplest arrangement, as shown in Fig. 1, an additional white element is provided in sequence after the gamut elements. Referring to Fig. 1, a series of columns of each color are composed of pixels 10 having color light emitting elements red **12**, green **14,** blue **16**, and white 18. In the vertical direction, the elements form a single colored striped line. In an orthogonal, horizontal direction, the colored lines alternate sequentially. It should be noted that the light emitting element arrangements shown in the embodiment described in Fig. 1 and in the embodiments described below can be reflected or rotated without changing their properties.

[0014] In the arrangement shown in Fig. 1, the additional white light emitting elements **18** are arranged to alternate with the green light emitting elements **14** so that the white and green elements are spatially symmetric, which may enhance the luminance resolution of the display since white and green both carry a relatively large amount of luminance information in a display.

[0015] Referring to Fig. 6, in a slightly different arrangement, the white and green elements **18** and **14** are arranged between the red and blue elements **12** and 16. The white element **18** may also be placed between the green **14** and blue 16 elements (not shown). These two configurations have the advantage of positioning the additional white element more centrally within the pixel. Since white light is a combination of colors, positioning the white light element in a central position within the pixel may provide a viewer with an experience more consistent with the experience from a conventional stripe pattern.

[0016] Referring to Fig. 7, in an alternative embodiment, the additional element **18** may be arranged with respect to the gamut elements to spatially integrate the light from the pixel **10.** For example, the additional element **18** may be located beneath (or above) the gamut elements. Since the additional (in-gamut) element emits light that would otherwise be emitted from gamut elements, locating the additional element **18** such that its light emission is located near all the gamut elements will provide compatibility with a stripe arrangement and form a spatially integrated light source.

[0017] Referring to Fig. 11, a circuit pattern diagram for an active matrix display of the type shown in Fig. 7 is shown. The light emitting elements are connected to select lines **113,** data lines **112a** or **112b** or **112c** or **112d,** power lines **111a, 111b** or **111c,** and capacitor lines **114.** To operate the display, rows of light emitting elements are selected by applying a voltage to a single select line, which turns on the select transistors **120** of the connected light emitting elements. The brightness level for each light emitting element is controlled by a voltage signal, which is held on the data lines. The storage capacitor **130** of each selected element is then charged to the voltage level of the associated data line **112a, 112b**, **112c** or **112d**. Within each light emitting element, the storage capacitor is connected to the gate of the power transistor **140** so that the voltage level held on the storage capacitor regulates the current flow through the power transistor **140** to the light emitting elements' organic EL element **11** and thereby brightness is controlled. Each row is then un-selected by applying a voltage signal to the select line **113** which turns off the select transistor **120**. The data line **112** voltages are then set to the levels desired for the next row and the select line of the next row is turned on. This is repeated for every row of light emitting elements. The storage capacitors **130** maintain the data voltage until the row is selected again during the next image frame.

[0018] The power lines are typically connected to a common voltage level for all light emitting elements. As shown here, the light emitting elements **12, 14,** and **16** are connected to a different select line than light emitting element **18**. This means that the brightness level of light emitting element **18** is written at a different time than that of light emitting elements **12, 14**, and **16**. However, an alternate configuration where a pixel is defined as being composed of light emitting elements **18, 12a, 14a,** and **16a,** would result in the brightness level of all light emitting elements within the pixel being adjusted simultaneously and is understood to be within the scope of the invention.

[0019] Fig. 12 shows a layout pattern diagram for the active matrix circuit of Fig. 11 as described above. The drive circuitry components are fabricated using conventional integrated circuit technologies. Light emitting element **12**, for example, consists of a select transistor **120a** formed from a first semiconductor region **121a** using techniques well known in the art. Similarly, a power transistor **140a** is formed in a second semiconductor region **141a.** The first semiconductor region **121a** and second semiconductor region **141a** are typically formed in the same semiconductor layer.

[0020] This semiconductor layer is typically silicon which may be amorphous, polycrystalline, or crystalline. This first semiconductor region **121a** also forms one side of the storage capacitor 130a. Over the first semiconductor region 121a and second semiconductor region **141a** is an insulating layer (not shown) that forms the gate insulator of the select transistor **120a,** the gate insulator for power transistor **140a,** and the insulating layer of the storage capacitor **130a.** The gate of the select transistor **120a** is formed from part of the select line **113a** which is formed in the first conductive layer.

[0021] The power transistor **140a** has a separate gate conductor **143a** also preferably formed in the first conductive layer. The other electrode of the storage capacitor **130a** is formed as part of capacitor line **114a,** also preferably from the first conductive layer. The power line **111a** and the data lines **112a** respectively, are preferably formed in a second conductive layer. One or more of the signal lines (e.g. select line **113a)** frequently cross at least one or more of the other signal lines (e.g. data line **112a),** which requires these lines to be fabricated from multiple conductive layers with at least one interlayer insulating layer (not shown). The organic EL element is formed by patterning a first electrode **181a** for each pixel as well as depositing one or more layers of organic EL media (not shown) and a second electrode (not shown).

[0022] Connections between layers are formed by etching holes (or vias) in the insulating layers such as the first via **122a** connecting data line 112a, to the first semiconductor region **121a** of the select transistor, the second via **142a** connecting the power transistor gate conductor **143a** to first semiconductor region 121a of the storage capacitor **130a** and the select transistor **120a**, the third via **146a** connecting the second semiconductor region **141a** of the power transistor to power line **111a,** and the fourth via **145a** connecting the second semiconductor region **141a** of the power transistor to the first electrode **181a.**

[0023] Over the first electrode, an inter-element insulating film is formed to reduce shorts between the anode and the cathode. Use of such insulating films over the first electrode is disclosed in US 6,246,179 issued June 12, 2001 to Yamada. The inter-element insulating film is coated over all the light emitting elements of the display and openings are made to allow the first electrodes to connect to the OLED layers (not shown). For light emitting element **12,** opening **191a** is formed in the interpixel dielectric over the first electrode **181a.** Opening **191a** defines the area of the light emitting element which will emit light. While use of the inter-element insulating film is preferred, it is not required for successful implementation of the invention.

[0024] Light emitting elements **14** and **16** are formed similarly to light emitting element **12** and are connected to data lines **112b** and **112c** respectively as well as to power lines **111b** and **112c** respectively.

[0025] Light emitting element **18** is connected to select line **113b,** capacitor line **114b,** data line **112d,** and power line **111c.** Light emitting element **18** can alternately be connected to power line **111b** or **111a** or be provided a unique power line not shared by light emitting elements having other colors by someone skilled in the art. Like light emitting element 12, light emitting element **18** consists of a select transistor **120b,** a storage capacitor **130b,** and power transistor **140b.** The select transistor and capacitor are constructed with a first semiconductor region **121b.** The power transistor is constructed with a second semiconductor region **141b** and a gate electrode **143b** connected to the first semiconductor region by via **142b,** to power line **111c** by via **146b,** and to the first electrode **181b** by via **145b.**

[0026] For light emitting element **18,** in order to connect the first semiconductor region **121b** to data line **112d**, data line **112a** must be crossed. This is done using first conductive bridge **150** which is preferably constructed of the first conductive layer. The conductive bridge is connected to data line **112d** by via **151b** and to the first semiconductor region by via **151a.** While use of first conductive bridge **150** is preferred, it is not required, and other connection methods including connecting the first semiconductor region **121b** directly to data line **112d** can be achieved by someone skilled in the art. Furthermore, depending on how the data lines are arranged, the conductive bridge maybe applied to a light emitting element other than light emitting element **18**. For example, if the locations of data line **112a** and data line **112d** were reversed, then the conductive bridge may be applied to light emitting element **12** instead of light emitting element **18.** Furthermore, more than one conductive bridge may be used to pass data lines on more than one light emitting element.

[0027] Light emitting element 18 also preferably uses a second conductive bridge **152** to connect the second capacitor electrode **131** to the capacitor line **114b** bridging over the select line **113b.** The second conductive bridge **152** is preferably constructed in the second conductive layer. The second conductive bridge **152** connects to the second capacitor electrode **131** by via **153b** and to capacitor line **114b** by via **153a.** As with the first conductive bridge **150,** by rearranging the components and connection lines, the second conductive bridge may be located on a light emitting element (or more than one light emitting element) other than light emitting element **18**. Variations of the light emitting elements can be constructed without a second conductive bridge if the select lines and capacitor lines are fabricated of different conductive layers.

[0028] The first electrode **181b** of light emitting element **18** stretches across several signal lines such as power lines **111a** and **111b** as well as data lines **112b** and **112c.** These regions are not emitting in a bottom emission configuration and may be covered with inter-pixel dielectric. This results in three separate openings in the inter-element dielectric **191x, 191y**, and **191z** which results in three separate emitting regions for light emitting element **18**.

[0029] The light emitting elements of the present invention have been shown and have been described as configured in a bottom-emission configuration. If the device were to be configured in a top-emission configuration, the first electrodes can be increased in size and made to extend over the other various circuit components and signal lines. The openings in the inter-pixel dielectric can be increased in a similar fashion. In this case, the light emitting element 18 would not need to be provided multiple separate openings, and thereby multiple separate emitting regions, but could instead be provided one larger continuous opening and emitting region. Such a configuration is envisioned as being consistent with the present invention.

[0030] While the above embodiments have been described with reference to a specific configuration of the active matrix circuit, several variations of the conventional circuit which are known in the art can also be applied to the present invention by someone skilled in the art. For example, one variation such as that shown in US 5,550,066 issued August 27, 1996 to Tang et al. does not have a separate capacitor line but instead connects the capacitors directly to the power line. A second variation as shown in US 6,476,419 issued November 5, 2002 to Yasuda uses two capacitors disposed directly over each other where the first capacitor is fabricated between the semiconductor layer and the gate conductor layer and the second capacitor is fabricated between the gate conductor layer and the second conductor layer. Either of these variations can be applied to the present invention by someone skilled in the art.

[0031] While the circuit requires a select transistor and a power transistor for each light emitting element, several variations of these transistor designs are known in the art. For example, single and multi-gate versions of transistors are known and have been applied to the select transistors in prior art. A single gate transistor contains a gate, a source and a drain. An example of the use of a single gate type of transistor for the select transistor is shown in US 6,429,599 issued August 6, 2002 to Yokoyama. A double transistor contains at least two gates electrically connected together and therefore a source, a drain, and at least one intermediate source-drain between the gates. An example of the use of a multi-gate type of transistor for the select transistor is shown in US 6,476,419, referenced above. This type of transistor can be represented in a circuit schematic by a single transistor or two or more transistors in series which have their gates connected and the source of one transistor connected directly to the drain of the second transistor. While the performance of these transistor designs may differ, both types of transistors serve the same function in the circuit and either type can be applied to the present invention by someone skilled in the art. The example of the preferred embodiment of the present invention is shown with a multi-gate type select transistor **120** represented by a single transistor symbol.

[0032] Also known in the art is the use of multiple parallel transistors to which is typically applied the power transistor **140**. Multiple parallel transistors are described in US 6,501,448 issued December 31, 2002 to Komiya et al. Multiple parallel transistors consist of two or more transistors with their sources, drains, and gates all electrically connected together. However, the location of the multiple transistors are separated in location within the pixels providing multiple parallel paths for current flow. The use of multiple parallel transistors has the advantage of providing robustness against variability and defects in the semiconductor layer manufacturing process. While the power transistor described in the embodiments of the present invention are shown as a single transistor, this can be replaced by multiple parallel transistors by someone skilled in the art and are therefore understood to be within the spirit of the invention.

[0033] Alternate circuit types are also known in the art such as constant current source driving schemes. An example of a constant current source device is provided in US 6,501,466 issued December 31, 2002 to Yamagishi et al. Alternate circuit types can be applied to the present invention by someone skilled in the art.

[0034] Turning now to Fig. 13, the vertical arrangement of the various layers from Fig. 12 are shown. The drive circuitry is disposed over substrate **20** and under OLED layer **310** in a manner herein described. Layer **310** includes a hole injecting layer **311**, a hole transporting layer **312**, a light emitting layer **313**, and an electron transporting layer **314.** Over the substrate **20**, a semiconductor layer is formed, doped, and patterned creating the second semiconductor region **141a**. A gate insulating layer **212** is formed over the semiconductor layer. Over the gate insulating layer **212**, a gate conductor is formed in the first conductor layer. The semiconductor layer is then doped to form source and drain regions on either sides of the gate conductor **143a.** A first interlayer insulator layer **213** is formed over the gate conductor **143a.** Over the first interlayer insulator layer **213**, a second conductor layer is deposited and patterned forming the first power lines (e.g. **111a)** and the data lines (e.g. **112a** and **112d**). A second interlayer insulator layer **214** is formed over the power and data lines (e.g. **111a, 112a**, etc.). The first electrode **181a** is formed over the second interlayer insulator layer **214.** The first electrode **181a** is patterned. Around the edges of the first electrode **181a**, an inter element dielectric film **220** is formed to reduce shorts between the first electrode **181a** and the second electrode **320**.

[0035] Referring to Fig. 14, an alternate arrangement of the drive circuitry is shown. In Fig. 14, the arrangement of the data lines and power lines has been configured such that there are two power lines **111a** and **111b** per pixel in a row. In this example, light emitting elements **14** and **18** share power line **111a.** Light emitting element **16** shares a power line **111b** with a light emitting element from an adjacent pixel. That is, light emitting element **14** is connected to a power line **111b** of a adjacent pixel. This arrangement has fewer power lines per pixel than the arrangement in Fig. 11 and each power line carries the current load from two light emitting elements.

[0036] Fig. 15 shows a layout pattern diagram for the active matrix circuit of Fig. 14 as described above. This pattern has the same transistor and capacitor components as described in Fig 12. In order to achieve the desired two power lines per pixel, several conductive bridge structures are utilized as described above. The first conductive bridge **154** is connected to the first semiconductor region **121a** of light emitting element **12** by via **155a** and to a power line **111b** by via **155b** bridging over data line **112d.** The second conductive bridge **152** connects the second capacitor electrode **131** of light emitting element **18** to the capacitor line **114b** bridging over the select line **113b.** The third conductive bridge **156** connects to the second semiconductor region **141b** of light emitting element **18** by via **157b** and to power line **111a** by via **157a.**

[0037] While these conductive bridges are shown as part of particular light emitting elements, they may be located on other light emitting elements other than those shown. While use of the conductive bridges is preferred, they are not required to successfully practice the present invention.

[0038] Referring now to Fig. 16, an alternate arrangement of the pixel circuit of the first embodiment is shown. In Fig. 16, the arrangement of the data lines and power lines for two adjacent pixels **10** and **9** have been configured such that there are three power lines **111a, 111b,** and **111c** for every two pixels in a row. In this example, light emitting elements **16, 18, 12b,** and **18b** are all connected to power line **111b.** This arrangement has fewer power lines per pixel than the arrangements in Fig. 11 and Fig. 14.

[0039] Fig. 17 shows a layout pattern diagram for the active matrix circuit of Fig. 16 as described above. This pattern has the same transistor and capacitor components as described in the Fig 12. In order to achieve the desired three power lines per two pixels, the layout of light emitting elements **12b, 14b, 16b,** and 18b are reversed with respect to light emitting elements **12, 14, 16**, and **18.** The power transistor **140c** of light emitting element **16** and the power transistor **140i** of light emitting element **12b** are both connected to power line **111b.** Therefore these transistors can be formed from the same semiconductor region **141c** and contact can be made between the semiconductor region **141c** and the power line **111b** using the same via **146i.** Similarly, the power transistor **140d** of light emitting element **18** and the power transistor **140L** of light emitting element **18b** are both connected to power line **111b.** Therefore these transistors can be formed from the same semiconductor region **141d** and contact can be made between the semiconductor region **141d** and the power line **111b** using the same via **146L.** While using the same via and semiconductor region for the above-mentioned transistors is desirable, it is not required to successfully practice the invention.

[0040] Referring to Fig. 8, in an alternative embodiment, the white element **18** is arranged near the center of the pixel **10**. Each pixel **10** includes the red **12,** green **14,** and blue **16** elements as conventionally arranged except that the center element **14** is smaller. The additional element **18** is located below (or above) the center element. Since a white element effectively emits light that would otherwise be emitted from all three color elements, locating the white element **18** such that the white light emission is located near the center of all three color elements will provide compatibility with a stripe arrangement.

[0041] Referring to Fig. 18, a layout pattern is shown where the white light emitting element **18** and the green light emitting element **14** are aligned into a single stripe as illustrated in Fig. 8. Any of the circuit layout examples described above can be made to drive this arrangement. The example shown in Fig. 18 shows a system with two power lines per pixel in a row. When arranged such that light emitting elements **14** and **18** form a stripe, only a single opening **190d** in the inter-element dielectric layer is required for light emitting element **18**.

[0042] The display is capable of presenting all of the colors presented by a standard three color, red, green, blue OLED display device. The color of the white OLED **18** may be designed to match the white point of the display. In this embodiment, the signal processor used to drive the display is configured to allow any gray value, including white, which would typically be presented using a combination of the red **12,** green **14,** and blue **16** color OLEDs to be created using primarily the white OLED **18**. To achieve this, the peak luminance of the white OLED **18** is designed to match the combined luminance of the red **12,** green **14,** and blue **16** OLEDs. That is, in a typical configuration where the prior art display would be designed to achieve a peak luminance of 100 cd/sq. m, the red **12,** green **14**, and blue 16 OLEDs will be set up to produce this peak luminance when they are all turned on to their maximum value and the white OLED **18** will also be designed to provide this same peak luminance.

[0043] It should be noted however, that under certain circumstances it may be desirable to design the color of the additional element **18** to provide a color point other than the display white point inside the gamut defined by the red, green, and blue elements. For example by biasing the color of the additional or "white" element **18** towards the color of one of the gamut elements, the designer reduces the reliance of the display on gamut element toward which the additional element is biased.

[0044] It may also be desirable to set the peak luminance of the additional element to other luminance values, including lower values, such as half the luminance of the peak luminance of the combined gamut elements which increases the reliance on the gamut elements while reducing the reliance on the additional element. The peak luminance of the additional element may also be designed to higher values, such as one and a half times the peak luminance of the combined gamut elements. However, this bias can result in loss of saturation for colors that are high in luminance that should be rendered as high in saturation.

[0045] Once the display is designed to provide the correct luminance value for each element, a suitable method is employed to map from a conventional three-channel data signal to a four-channel signal, for example using a suitable look-up table. Methods of generating lookup tables for converting a three channel data signal to drive a display having four or more color channels are well-known in the art, for example, US 6,075,514 issued June 13, 2000 to Ryan, provides one such method. Alternatively, the conversion may be accomplished in real time using an algorithm that specifies the conversion.

[0046] Because the transform from three to four colors is nondeterministic, (i.e. many colors in the conventional specification can be created with either combinations of the gamut elements alone or in one of many combinations with the additional element), different conversions are possible. However, by selecting the peak luminance of the additional element to match the combined peak luminances of the gamut elements, it is possible to perform the conversion to allow the additional element to provide as much luminance to each color as possible while maintaining saturation of all colors. This approach provides the maximum power savings possible with the present invention.

[0047] Various other embodiments of this invention may also be practiced. A second particularly useful embodiment includes the use of several different OLED materials that are doped to provide multiple colors. For example, the red **12**, green **14,** blue **16** and white **18** OLEDs may be composed of different OLED materials that are doped to produce different colored OLEDs. Referring to Fig. 10, in this embodiment, on each first electrode **22-28** a different layer of organic light emitting diode materials **62-68** respectively is formed. Over the organic light emitting diode materials a second electrode **32** is formed. Each of the organic light emitting diode materials (e.g., **62, 64, 66** and **68**) are formed from a hole injecting layer, a hole transporting layer, a light emitting layer, and an electron transporting layer as described in more detail below.

[0048] In this embodiment, the light emitting layer and potentially other layers within the stack of organic light emitting diode materials are selected to provide a red, green, blue, and white light emitting elements. One light emitting diode material **62** emits light primarily in the long wavelength or red portion of the visible spectrum. A second light emitting diode material **64** emits light primarily in the middle wavelength or green portion of the visible spectrum. A third light emitting diode material **66** emits light primarily in the short wavelength or blue portion of the visible spectrum. Finally, the fourth light emitting diode material **68** emits light in a broad range of wavelengths, producing a white OLED. In this way, the four different materials form a four-OLED display including red, green, blue, and white OLEDs.

[0049] In this implementation, OLEDs formed from materials that are doped to produce different colors may have significantly different luminance efficiencies and therefore it may be desirable to select a white OLED with chromaticity coordinates that are biased towards the chromaticity coordinate of the OLED with the lowest power efficiency. By selecting the chromaticity coordinate of the white OLED in this way, the element with the lowest power efficiency is replaced more often by the white OLED, decreasing the overall power usage.

[0050] Further, within this implementation, the different OLEDs may need to be driven at different levels to produce a color-balanced display. It is important to realize that the stability of OLED materials is inversely related to the current density that is used to drive the OLED. The lifetime of an OLED is influenced by the stability (i.e., the current density used to drive the OLED), therefore, the need to drive some elements with a higher current density may shorten the life of the OLEDs of the given color. Further, OLED materials that are doped to produce different colors typically have different luminance stabilities. That is, the change in luminance output that occurs over time is different for the different materials. To account for this, a material may be employed for the white OLED having a chromaticity coordinate that is positioned closer to the OLED with the shortest luminance stability than to the chromaticity coordinates of the other gamut defining OLEDs. Positioning the white OLED according to this criteria reduces the overall usage of the closest gamut-defining OLED, extending the lifetime of the closest gamut-defining OLED.

[0051] In the embodiments that have been discussed above, it is important to note that because the additional element is significantly more efficient than the gamut elements, the current density or power required to drive the additional element is significantly lower than for the gamut elements. It is also important to note that the luminance stability over time of the materials used to create the light emitting elements is typically related to the current density used to drive the elements through a very non-linear function in which the luminance stability over time of the material is much poorer when driven to higher current densities. In fact, the function used to describe this relationship can typically be described as a power function. For this reason, it is not desirable to drive any elements to current densities that are higher than a given threshold where the function describing the luminance stability over time is particularly steep. At the same time, it may be desirable to achieve maximum display luminance values that would typically require the gamut elements to be driven to this current density.

[0052] In the embodiments described thus far, the various light emitting elements will have different efficiencies and lifetimes. To optimize a display device for various applications it is useful to use different sized elements. For example, in applications for which black-and-white use dominates, the additional white OLED elements can be increased in size. It should also be recognized that as the amount of luminance that is dedicated to the additional element is manipulated, it may also be desirable to change their relative sizes. US 6,366,025 issued April 2, 2002 to Yamada, describes an electro-luminescent color display device having red, green, and blue light emitting elements having different areas to take into consideration the differing emission efficiencies and luminance ratios of the light emitting elements. The concept described by Yamada can be applied to the display device of the present invention. Referring to Fig. 9, a display having elements of varying areas depending on expected usage, efficiency and lifetime is shown.

[0053] In a preferred embodiment, the invention is employed in a device that includes Organic Light Emitting Diodes (OLEDs) which are composed of small molecule or polymeric OLEDs as disclosed in but not limited to US 4,769,292, issued September 6, 1988 to Tang et al., and US 5,061,569, issued October 29, 1991 to VanSlyke et al. Many combinations and variations of organic light emitting displays can be used to fabricate such a device.

[0054] The present invention can be employed in most OLED device configurations. These include very simple structures comprising a single anode and cathode to more complex devices, such as passive matrix displays comprised of orthogonal arrays of anodes and cathodes to form pixels, and active-matrix displays where each pixel is controlled independently, for example, with thin film transistors (TFTs).

[0055] There are numerous configurations of the organic layers wherein the present invention can be successfully practiced. A typical structure is shown in Fig. 19 and is comprised of a substrate **701,** an anode **703**, a hole-injecting layer **705**, a hole-transporting layer **707**, a light-emitting layer **709**, an electron-transporting layer **711**, and a cathode **713**. These layers are described in detail below. Note that the substrate may alternatively be located adjacent to the cathode, or the substrate may actually constitute the anode or cathode. The organic layers between the anode and cathode are conveniently referred to as the organic EL element. The total combined thickness of the organic layers is preferably less than 500 nm.

[0056] The anode and cathode of the OLED are connected to a voltage/current source 850 through electrical conductors **860**. The OLED is operated by applying a potential between the anode and cathode such that the anode is at a more positive potential than the cathode. Holes are injected into the organic EL element from the anode and electrons are injected into the organic EL element at the anode. Enhanced device stability can sometimes be achieved when the OLED is operated in an AC mode where, for some time period in the cycle, the potential bias is reversed and no current flows. An example of an AC-driven OLED is described in US 5,552,678.

[0057] The OLED device of this invention is typically provided over a supporting substrate where either the cathode or anode can be in contact with the substrate. The electrode in contact with the substrate is conveniently referred to as the bottom electrode. Conventionally, the bottom electrode is the anode, but this invention is not limited to that configuration. The substrate can either be transmissive or opaque. In the case wherein the substrate is transmissive, a reflective or light absorbing layer is used to reflect the light through the cover or to absorb the light, thereby improving the contrast of the display. Substrates can include, but are not limited to, glass, plastic, semiconductor materials, silicon, ceramics, and circuit board materials. Of course it is necessary to provide a light-transparent top electrode.

[0058] When EL emission is viewed through anode **703**, the anode should be transparent or substantially transparent to the emission of interest. Common transparent anode materials used in this invention are indium-tin oxide (ITO), indium-zinc oxide (IZO) and tin oxide, but other metal oxides can work including, but not limited to, aluminum- or indium-doped zinc oxide, magnesium-indium oxide, and nickel-tungsten oxide. In addition to these oxides, metal nitrides, such as gallium nitride, and metal selenides, such as zinc selenide, and metal sulfides, such as zinc sulfide, can be used as the anode. For applications where EL emission is viewed only through the cathode electrode, the transmissive characteristics of anode are immaterial and any conductive material can be used, transparent, opaque or reflective. Example conductors for this application include, but are not limited to, gold, iridium, molybdenum, palladium, and platinum. Typical anode materials, transmissive or otherwise, have a work function of 4.1 eV or greater. Desired anode materials are commonly deposited by any suitable means such as evaporation, sputtering, chemical vapor deposition, or electrochemical means. Anodes can be patterned using well-known photolithographic processes. Optionally, anodes may be polished prior to application of other layers to reduce surface roughness so as to minimize shorts or enhance reflectivity.

[0059] While not always necessary, it is often useful to provide a hole-injecting layer **705** between anode **703** and hole-transporting layer **707**. The hole-injecting material can serve to improve the film formation property of subsequent organic layers and to facilitate injection of holes into the hole-transporting layer. Suitable materials for use in the hole-injecting layer include, but are not limited to, porphyrinic compounds as described in US 4,720,432, plasma-deposited fluorocarbon polymers as described in US 6,208,075, and some aromatic amines, for example, m-MTDATA (4,4',4"-tris[(3-methylphenyl)phenylamino]triphenylamine). Alternative hole-injecting materials reportedly useful in organic EL devices are described in EP 0 891 121 A1 and EP 1 029 909 A1.

[0060] The hole-transporting layer **707** contains at least one hole-transporting compound such as an aromatic tertiary amine, where the latter is understood to be a compound containing at least one trivalent nitrogen atom that is bonded only to carbon atoms, at least one of which is a member of an aromatic ring. In one form the aromatic tertiary amine can be an arylamine, such as a monoarylamine, diarylamine, triarylamine, or a polymeric arylamine. Exemplary monomeric triarylamines are illustrated by Klupfel et al. US 3,180,730. Other suitable triarylamines substituted with one or more vinyl radicals and/or comprising at least one active hydrogen containing group are disclosed by Brantley et al US 3,567,450 and 3,658,520.

[0061] A more preferred class of aromatic tertiary amines are those which include at least two aromatic tertiary amine moieties as described in US 4,720,432 and 5,061,569. The hole-transporting layer can be formed of a single or a mixture of aromatic tertiary amine compounds. Illustrative of useful aromatic tertiary amines are the following:

1,1-Bis(4-di-p-tolylaminophenyl)cyclohexane
1,1-Bis(4-di-p-tolylaminophenyl)-4-phenylcyclohexane
4,4'-Bis(diphenylamino)quadriphenyl
Bis(4-dimethylamino-2-methylphenyl)-phenylmethane
N,N,N-Tri(p-tolyl)amine
4-(di-p-tolylamino)-4'-[4(di-p-tolylamino)-styryl] stilbene
N,N,N',N'-Tetra-p-tolyl-4-4'-diaminobiphenyl
N,N,N',N'-Tetraphenyl-4,4'-diaminobiphenyl
N,N,N\N'-tetra-1-naphthyl-4,4'-diaminobiphenyl
N,N,N',N'-tetra-2-naphthyl-4,4'-diaminobiphenyl
N-Phenylcarbazole
4,4'-Bis[N-(1-naphthyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(1-naphthyl)-N-(2-naphthyl)amino]biphenyl
4,4"-Bis[N-(1-naphthyl)-N-phenylamino]p-terphenyl
4,4'-Bis[N-(2-naphthyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(3-acenaphthenyl)-N-phenylamino]biphenyl
1,5-Bis[N-(1-naphthyl)-N-phenylamino]naphthalene
4,4'-Bis[N-(9-anthryl)-N-phenylamino]biphenyl
4,4"-Bis[N-(-anthryl)-N-phenylamino]-p-terphenyl
4,4'-Bis[N-(2-phenanthryl)-N-phenylamino]biphenyl
4,4'-Bis[N-(8-fluoranthenyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(2-pyrenyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(2-naphthacenyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(2-perylenyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(1-coronenyl)-N-phenylamino]biphenyl
2,6-Bis(di-p-tolylamino)naphthalene
2,6-Bis[di-(1-naphthyl)amino]naphthalene
2,6-Bis[N-(1-naphthyl)-N-(2-naphthyl)amino]naphthalene
N,N,N',N'-Tetra(2-naphthyl)-4,4"-diamino-p-terphenyl

4,4'-Bis{N-phenyl-N-[4-(1-naphthyl)-phenyl]amino}biphenyl
4,4'-Bis[N-phenyl-N-(2-pyrenyl)amino]biphenyl
2,6-Bis[N,N-di(2-naphthyl)amine]fluorene
1,5-Bis[N-(1-naphthyl)-N-phenylamino]naphthalene
4,4',4"-tris[(3-methylphenyl)phenylamino]triphenylamine

[0062] Another class of useful hole-transporting materials includes polycyclic aromatic compounds as described in EP 1 009 041. Tertiary aromatic amines with more than two amine groups may be used including oligomeric materials. In addition, polymeric hole-transporting materials can be used such as poly(N-vinylcarbazole) (PVK), polythiophenes, polypyrrole, polyaniline, and copolymers such as poly(3,4-ethylenedioxythiophene) / poly(4-styrenesulfonate) also called PEDOT/PSS.

[0063] As more fully described in US 4,769,292 and 5,935,721, the light-emitting layer (LEL) **709** of the organic EL element includes a luminescent or fluorescent material where electroluminescence is produced as a result of electron-hole pair recombination in this region. The light-emitting layer can be comprised of a single material, but more commonly consists of a host material doped with a guest compound or compounds where light emission comes primarily from the dopant and can be of any color. The host materials in the light-emitting layer can be an electron-transporting material, as defined below, a hole-transporting material, as defined above, or another material or combination of materials that support hole-electron recombination. The dopant is usually chosen from highly fluorescent dyes, but phosphorescent compounds, e.g., transition metal complexes as described in WO 98/55561, WO 00/18851, WO 00/57676, and WO 00/70655 are also useful. Dopants are typically coated as 0.01 to 10 % by weight into the host material. Polymeric materials such as polyfluorenes and polyvinylarylenes (e.g., poly(p-phenylenevinylene), PPV) can also be used as the host material. In this case, small molecule dopants can be molecularly dispersed into the polymeric host, or the dopant could be added by copolymerizing a minor constituent into the host polymer.

[0064] An important relationship for choosing a dye as a dopant is a comparison of the bandgap potential which is defined as the energy difference between the highest occupied molecular orbital and the lowest unoccupied molecular orbital of the molecule. For efficient energy transfer from the host to the dopant molecule, a necessary condition is that the band gap of the dopant is smaller than that of the host material. For phosphorescent emitters it is also important that the host triplet energy level of the host be high enough to enable energy transfer from host to dopant.

[0065] Host and emitting molecules known to be of use include, but are not limited to, those disclosed in US 4,768,292; 5,141,671; 5,150,006; 5,151,629; 5,405,709; 5,484,922; 5,593,788; 5,645,948; 5,683,823; 5,755,999; 5,928,802; 5,935,720; 5,935,721; and 6,020,078.

[0066] Metal complexes of 8-hydroxyquinoline (oxine) and similar derivatives constitute one class of useful host compounds capable of supporting electroluminescence. Illustrative of useful chelated oxinoid compounds are the following:

CO-1: Aluminum trisoxine [alias, tris(8-quinolinolato)aluminum(III)]
CO-2: Magnesium bisoxine [alias, bis(8-quinolinolato)magnesium(II)]
CO-3: Bis[benzo {f}-8-quinolinolato]zinc (II)
CO-4: Bis(2-methyl-8-quinolinolato)aluminum(III)-□-oxo-bis(2-methyl-8-quinolinolato) aluminum(III)
CO-5: Indium trisoxine [alias, tris(8-quinolinolato) indium]
CO-6: Aluminum tris(5-methyloxine) [alias, tris (5-methyl-8-quinolinolato) aluminum(III)]
CO-7: Lithium oxine [alias, (8-quinolinolato)lithium (I)]
CO-8: Gallium oxine [alias, tris(8-quinolinolato)gallium(III)]
CO-9: Zirconium oxine [alias, tetra(8-quinolinolato) zirconium(IV))

[0067] Other classes of useful host materials include, but are not limited to: derivatives of anthracene, such as 9,10-di-(2-naphthyl)anthracene and derivatives thereof as described in US 5,935,721, distyrylarylene derivatives as described in US 5,121,029, and benzazole derivatives, for example, 2, 2', 2"-(1,3,5-phenylene)tris [1-phenyl-1H-benzimidazole]. Carbazole derivatives are particularly useful hosts for phosphorescent emitters.

[0068] Useful fluorescent dopants include, but are not limited to, derivatives of anthracene, tetracene, xanthene, perylene, rubrene, coumarin, rhodamine, and quinacridone, dicyanomethylenepyran compounds, thiopyran compounds, polymethine compounds, pyrilium and thiapyrilium compounds, fluorene derivatives, periflanthene derivatives, indenoperylene derivatives, bis (azinyl)amine boron compounds, bis(azinyl)methane compounds, and carbostyryl compounds.

[0069] Preferred thin film-forming materials for use in forming the electron-transporting layer **711** of the organic EL elements of this invention are metal chelated oxinoid compounds, including chelates of oxine itself (also commonly referred to as 8-quinolinol or 8-hydroxyquinoline). Such compounds help to inject and transport electrons, exhibit high levels of performance, and are readily fabricated in the form of thin films. Exemplary oxinoid compounds were listed previously.

[0070] Other electron-transporting materials include various butadiene derivatives as disclosed in US 4,356,429 and various heterocyclic optical brighteners as described in US 4,539,507. Benzazoles and triazines are also useful electron-transporting materials.

[0071] When light emission is viewed solely through the anode, the cathode 113 used in this invention can be comprised of nearly any conductive material. Desirable materials have good film-forming properties to ensure good contact with the underlying organic layer, promote electron injection at low voltage, and have good stability. Useful cathode materials often contain a low work function metal (< 4.0 eV) or metal alloy. One preferred cathode material is comprised of a Mg:Ag alloy wherein the percentage of silver is in the range of 1 to 20 %, as described in US 4,885,221. Another suitable class of cathode materials includes bilayers comprising a thin electron-injection layer (EIL) in contact with the organic layer (e.g., ETL) which is capped with a thicker layer of a conductive metal. Here, the EIL preferably includes a low work function metal or metal salt, and if so, the thicker capping layer does not need to have a low work function. One such cathode is comprised of a thin layer of LiF followed by a thicker layer of A1 as described in US 5,677,572. Other useful cathode material sets include, but are not limited to, those disclosed in US 5,059,861, 5,059,862, and 6,140,763.

[0072] When light emission is viewed through the cathode, the cathode must be transparent or nearly transparent. For such applications, metals must be thin or one must use transparent conductive oxides, or a combination of these materials. Optically transparent cathodes have been described in more detail in US 4,885,211, US 5,247,190, JP 3,234,963, US 5,703,436, US 5,608,287, US 5,837,391, US 5,677,572, US 5,776,622, US 5,776,623, US 5,714,838, US 5,969,474, US 5,739,545, US 5,981,306, US 6,137,223, US 6,140,763, US 6,172,459, EP 1 076 368, US 6,278,236, and US 6,284,393. Cathode materials are typically deposited by evaporation, sputtering, or chemical vapor deposition. When needed, patterning can be achieved through many well known methods including, but not limited to, through-mask deposition, integral shadow masking, for example, as described in US 5,276,380 and EP 0 732 868, laser ablation, and selective chemical vapor deposition.

[0073] In some instances, layers **709** and **711** can optionally be collapsed into a single layer that serves the function of supporting both light emission and electron transportation. It also known in the art that emitting dopants may be added to the hole-transporting layer, which may serve as a host. Multiple dopants may be added to one or more layers in order to create a white-emitting OLED, for example, by combining blue- and yellow-emitting materials, cyan- and red-emitting materials, or red-, green-, and blue-emitting materials. White-emitting devices are described, for example, in EP 1 187 235, US 20020025419, EP 1 182 244, US 5,683,823, US 5,503,910, US 5,405,709, and US 5,283,182.

[0074] Additional layers such as electron or hole-blocking layers as taught in the art may be employed in devices of this invention. Hole-blocking layers are commonly used to improve efficiency of phosphorescent emitter devices, for example, as in US 20020015859.

[0075] This invention may be used in so-called stacked device architecture, for example, as taught in US 5,703,436 and US 6,337,492.

[0076] The organic materials mentioned above are suitably deposited through a vapor-phase method such as sublimation, but can be deposited from a fluid, for example, from a solvent with an optional binder to improve film formation. If the material is a polymer, solvent deposition is useful but other methods can be used, such as sputtering or thermal transfer from a donor sheet. The material to be deposited by sublimation can be vaporized from a sublimator "boat" often comprised of a tantalum material, e.g., as described in US 6,237,529, or can be first coated onto a donor sheet and then sublimed in closer proximity to the substrate. Layers with a mixture of materials can utilize separate sublimator boats or the materials can be pre-mixed and coated from a single boat or donor sheet. Patterned deposition can be achieved using shadow masks, integral shadow masks (US 5,294,870), spatially-defined thermal dye transfer from a donor sheet (US 5,688,551, 5,851,709 and 6,066,357) and inkjet method (US 6,066,357).

[0077] Most OLED devices are sensitive to moisture or oxygen, or both, so they are commonly sealed in an inert atmosphere such as nitrogen or argon, along with a desiccant such as alumina, bauxite, calcium sulfate, clays, silica gel, zeolites, alkaline metal oxides, alkaline earth metal oxides, sulfates, or metal halides and perchlorates. Methods for encapsulation and desiccation include, but are not limited to, those described in US 6,226,890. In addition, barrier layers such as SiOx, Teflon, and alternating inorganic/polymeric layers are known in the art for encapsulation.

[0078] OLED devices of this invention can employ various well-known optical effects in order to enhance its properties if desired. This includes optimizing layer thicknesses to yield maximum light transmission, providing dielectric mirror structures, replacing reflective electrodes with light-absorbing electrodes, providing anti glare or anti-reflection coatings over the display, providing a polarizing medium over the display, or providing colored, neutral density, or color conversion filters over the display. Filters, polarizers, and anti-glare or anti-reflection coatings may be specifically provided over the cover or an electrode protection layer beneath the cover.

Claims

1. A color OLED display, comprising:

a) an array of light emitting OLED pixels, each pixel having three or more gamut elements for emitting different colors of light specifying a gamut and at least one additional element for emitting a color of light within the gamut and wherein the power efficiency of the additional element is higher than the power efficiency of at least one of the three or more gamut elements;

b) wherein all of the gamut elements for each color in the display are arranged in a first direction in a line such that no differently colored gamut element is in the line;

c) wherein the colored gamut elements are arranged in a second direction orthogonal to the first direction in a line such that the colors of the gamut elements alternate in that line; and

d) wherein the additional elements are arranged in lines in both the first and second directions.

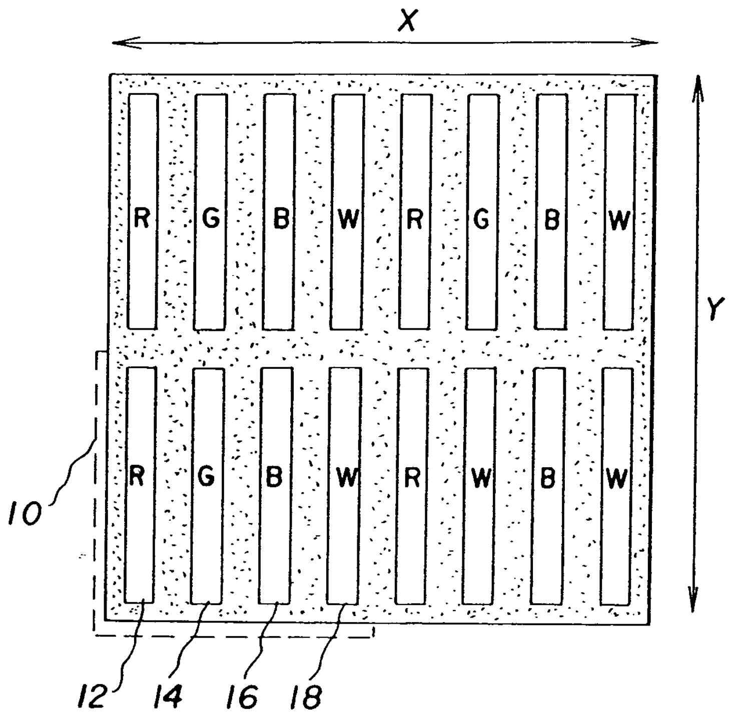


FIG. 1

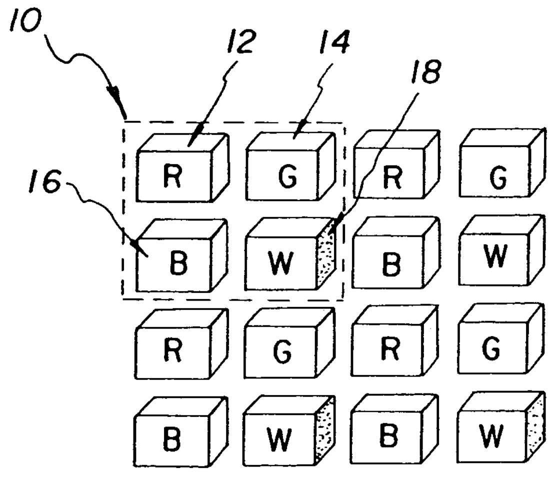


FIG. 2

PRIOR ART

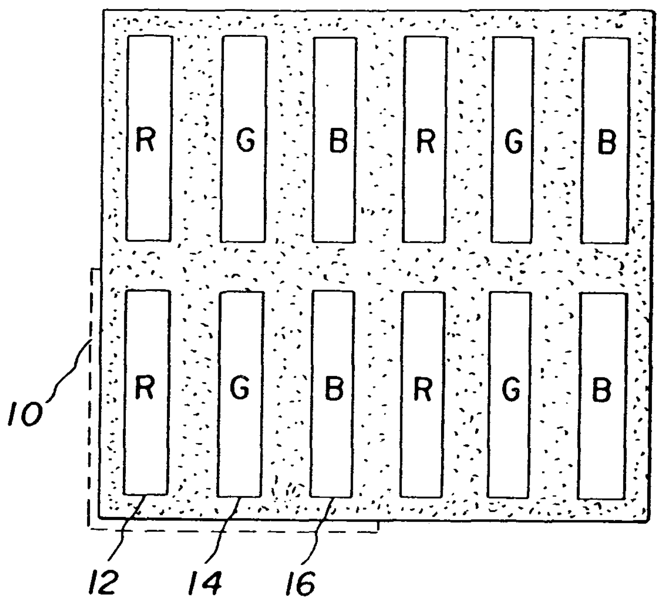


FIG. 3

PRIOR ART

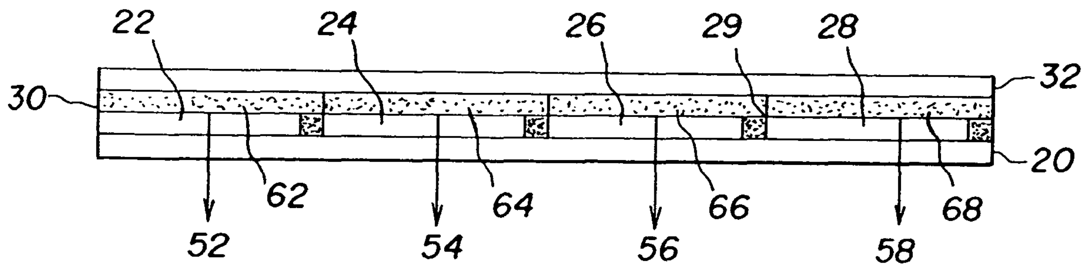


FIG. 10

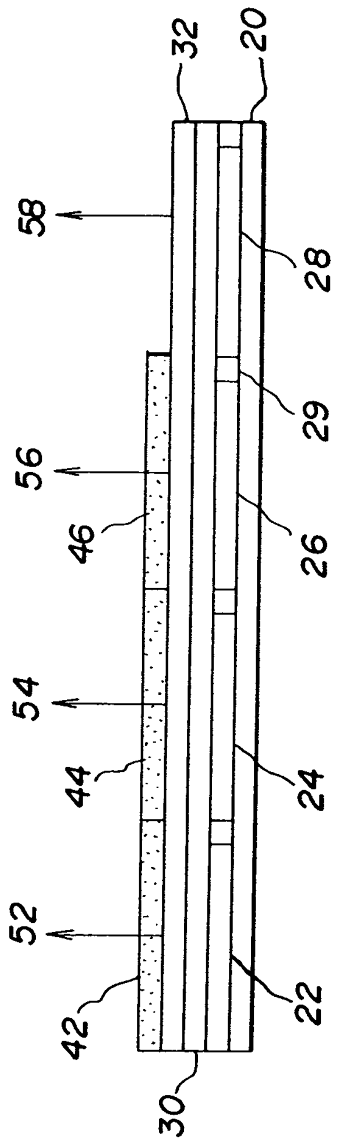

58
32
20
28
29
56
46
26
54
44
24
52
42
22
30

FIG. 4

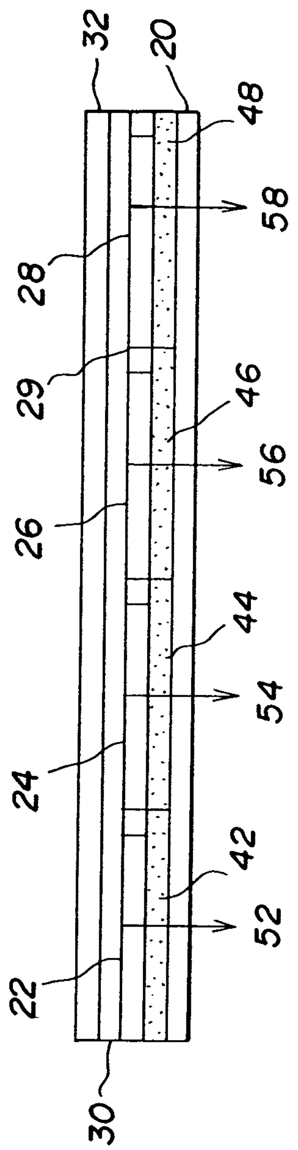

32
20
48
58
28
29
46
56
26
44
54
24
42
52
22
30

FIG. 5

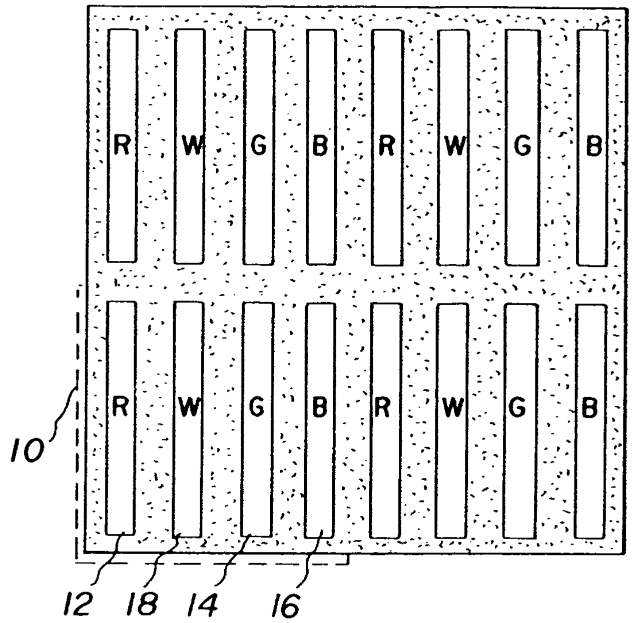

R
W
G
B
R
W
G
B
R
W
G
B
R
W
G
B
10
12
18
14
16

FIG. 6

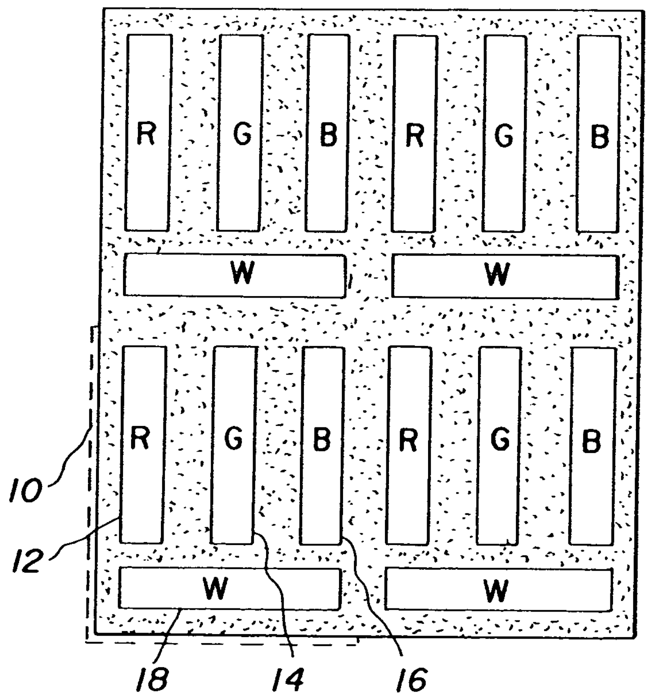

R
G
B
R
G
B
W
W
R
G
B
R
G
B
W
W
10
12
18
14
16

FIG. 7

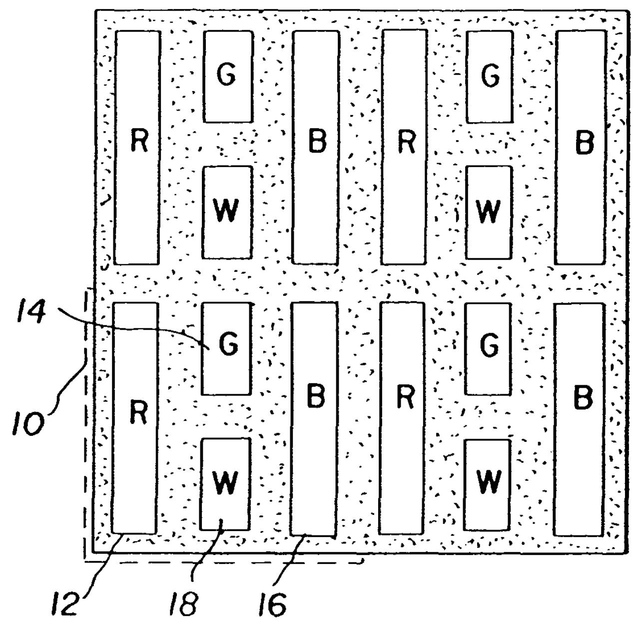

G
G
R
B
R
B
W
W
14
G
G
10
R
B
R
B
W
W
12
18
16

FIG. 8

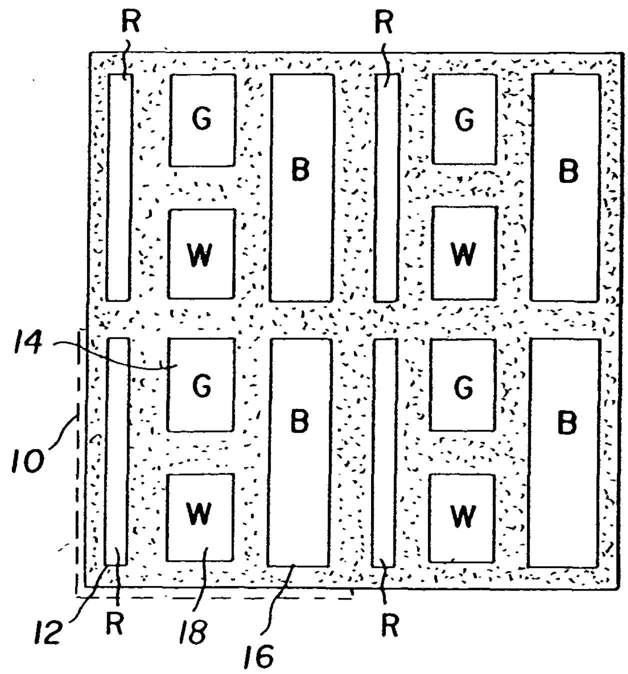

R
R
G
G
B
B
W
W
14
G
G
10
B
B
W
W
12
R
18
16
R

FIG. 9

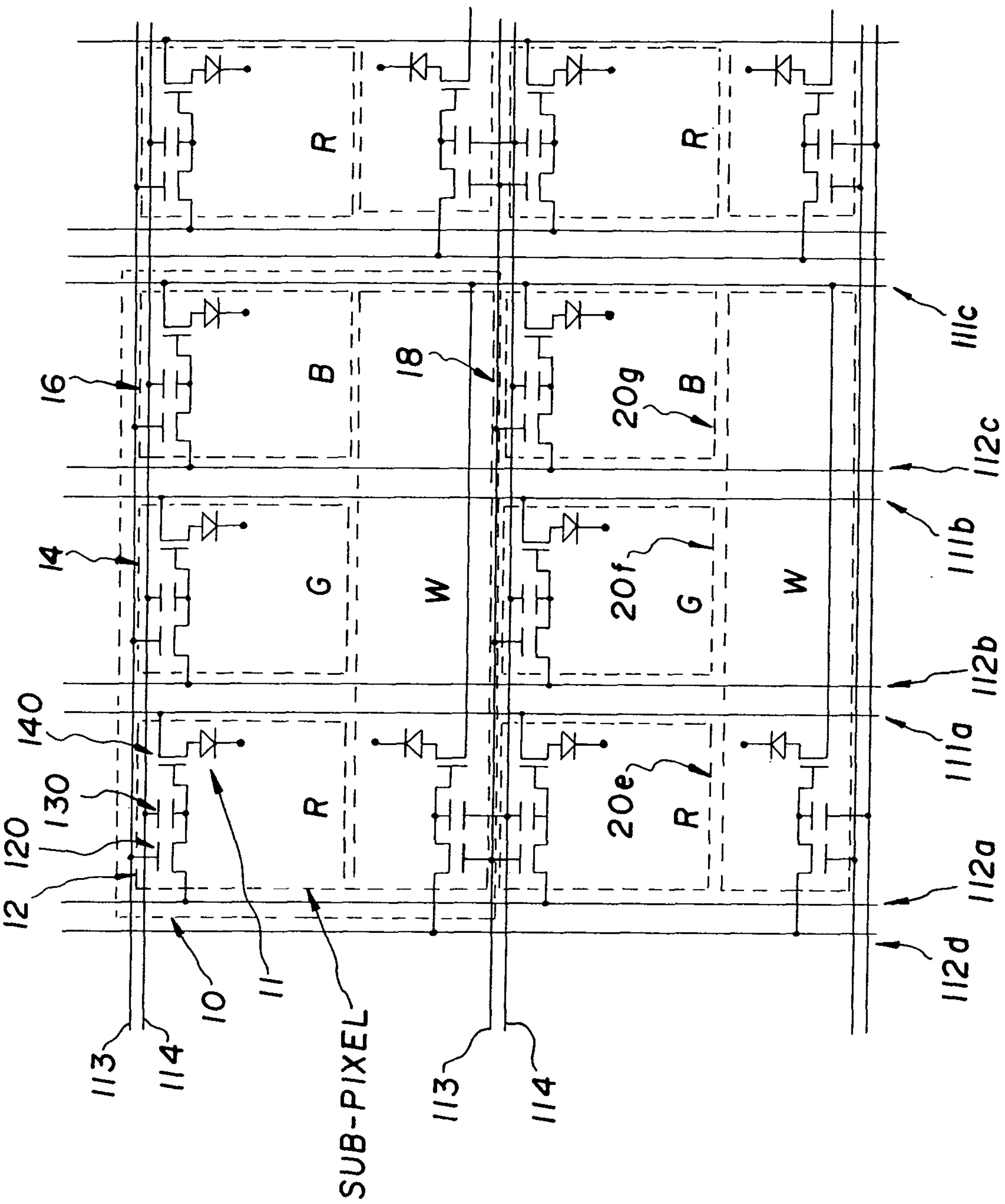
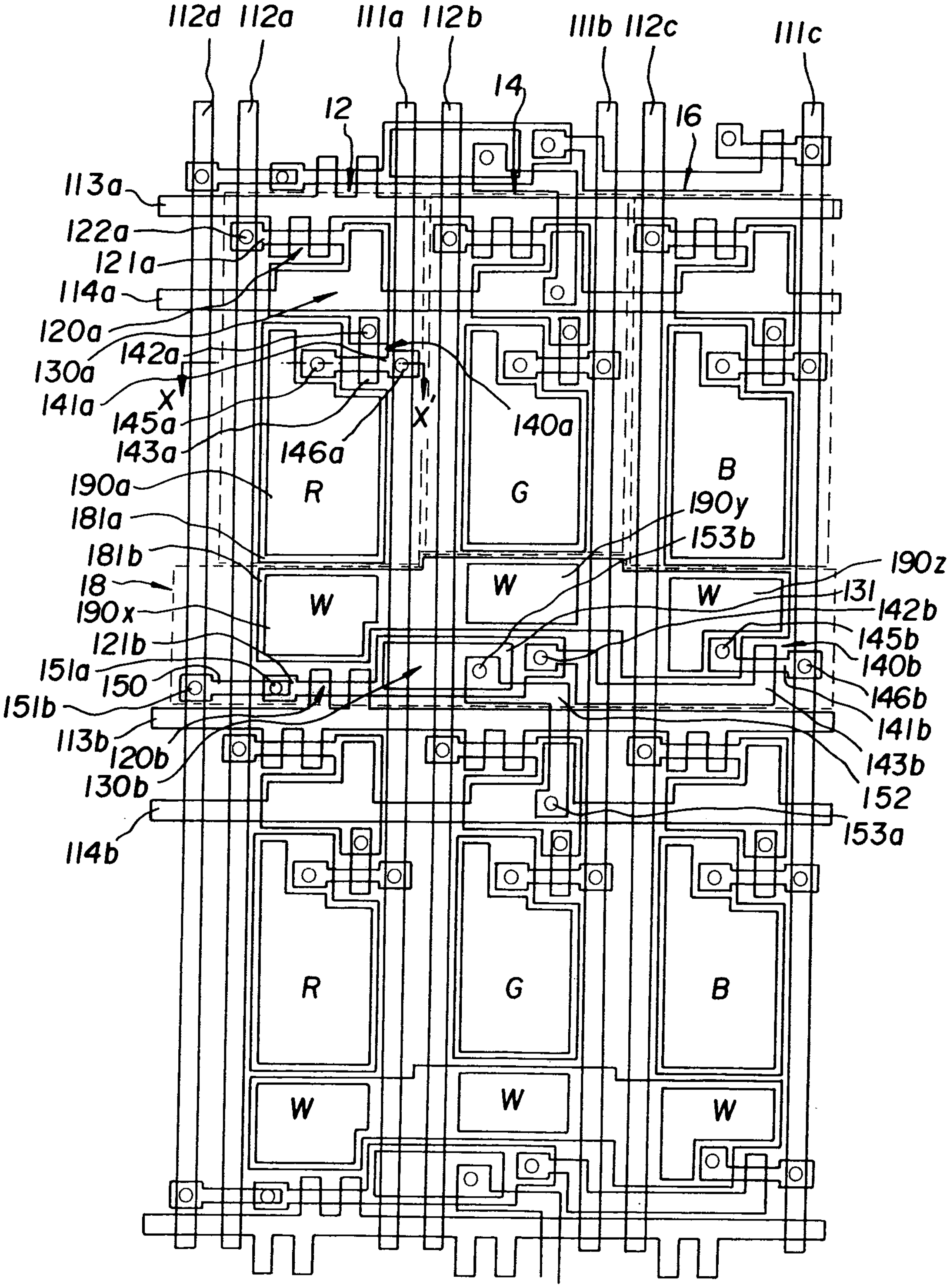

16
14
140
130
120
12
10
11
SUB-PIXEL
113
114
113
114
18
20g
20f
20e
R
G
B
W
111c
112c
111b
112b
111a
112a
112d

FIG. 11



112d
112a
111a
112b
111b
112c
111c
12
14
16
113a
122a
121a
114a
120a
130a
142a
141a
X
X'
145a
143a
146a
140a
190a
R
G
B
181a
190y
153b
181b
190z
18
W
W
W
131
142b
190x
145b
121b
140b
151a
150
146b
151b
141b
113b
120b
143b
130b
152
153a
114b
R
G
B
W
W
W

FIG. 12

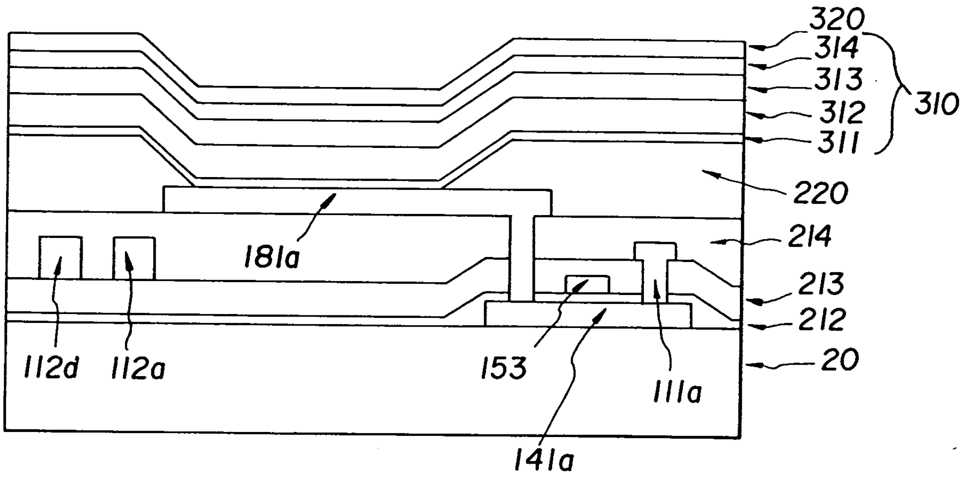

320
314
313
312
311
310
220
214
213
212
20
181a
112d
112a
153
111a
141a

FIG. 13

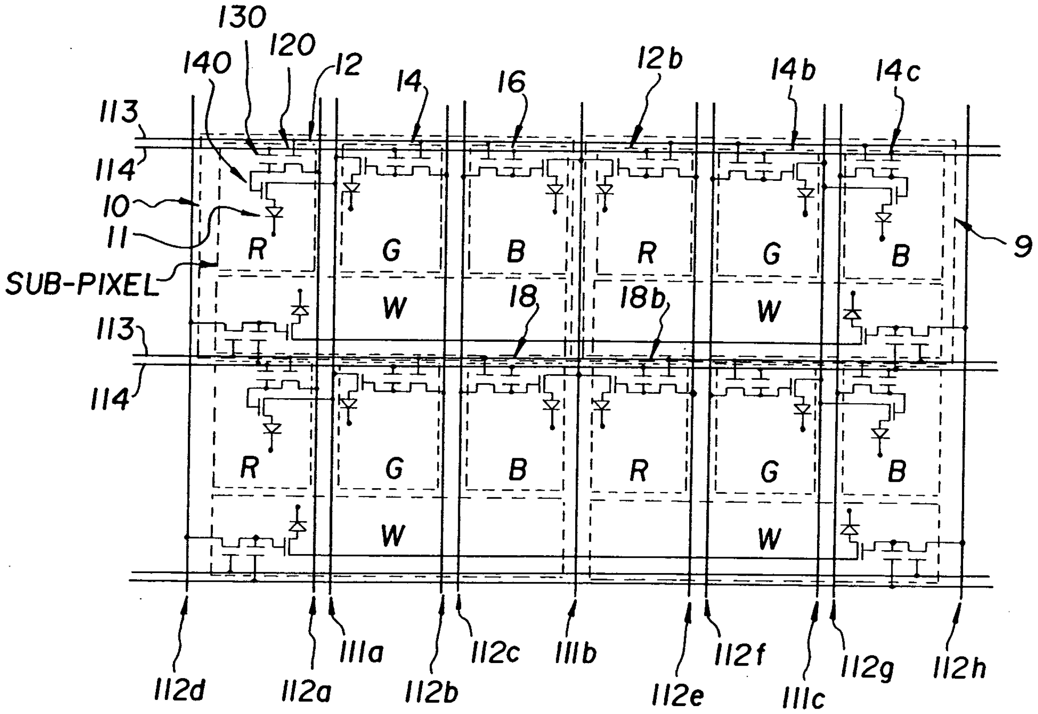
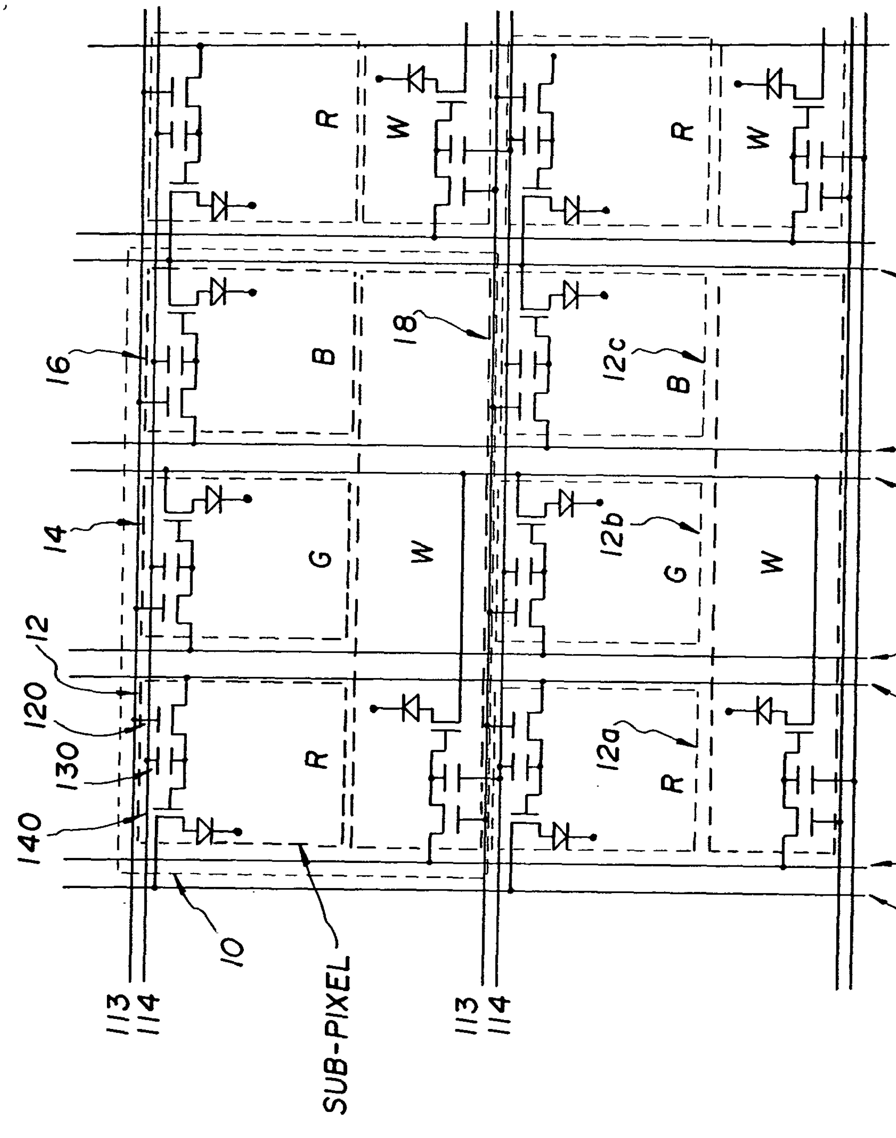

130
120
140
12
14
16
12b
14b
14c
113
114
10
11
SUB-PIXEL
R
G
B
W
18
18b
9
112d
112a
111a
112b
112c
111b
112e
112f
111c
112g
112h

FIG. 16

FIG. 14


16
14
12
120
130
140
10
SUB-PIXEL
113
114
113
114
R
W
B
18
G
W
R
R
W
12c
B
12b
G
W
12a
R
111b
112c
111a
112b
112a
112d
111b

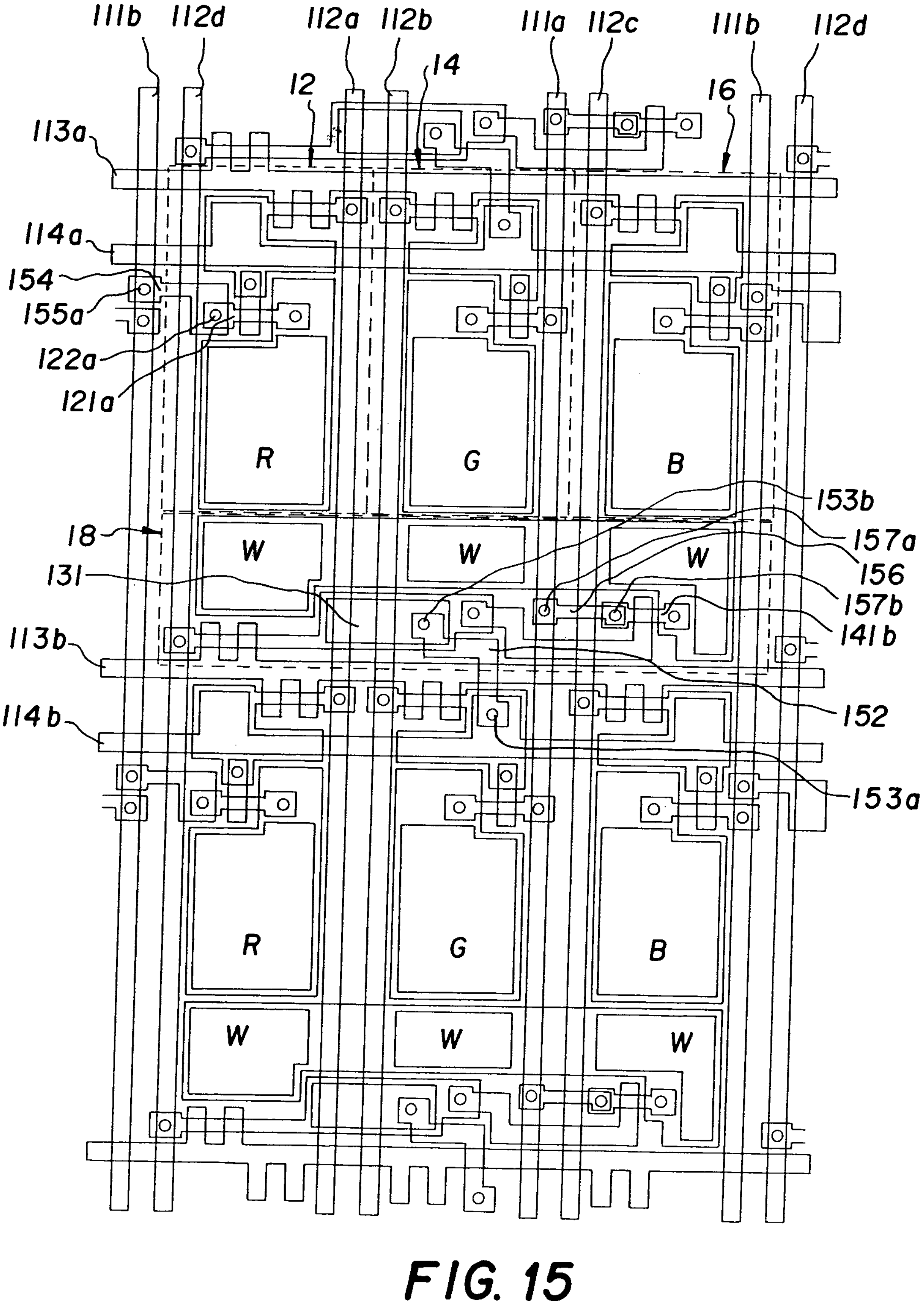
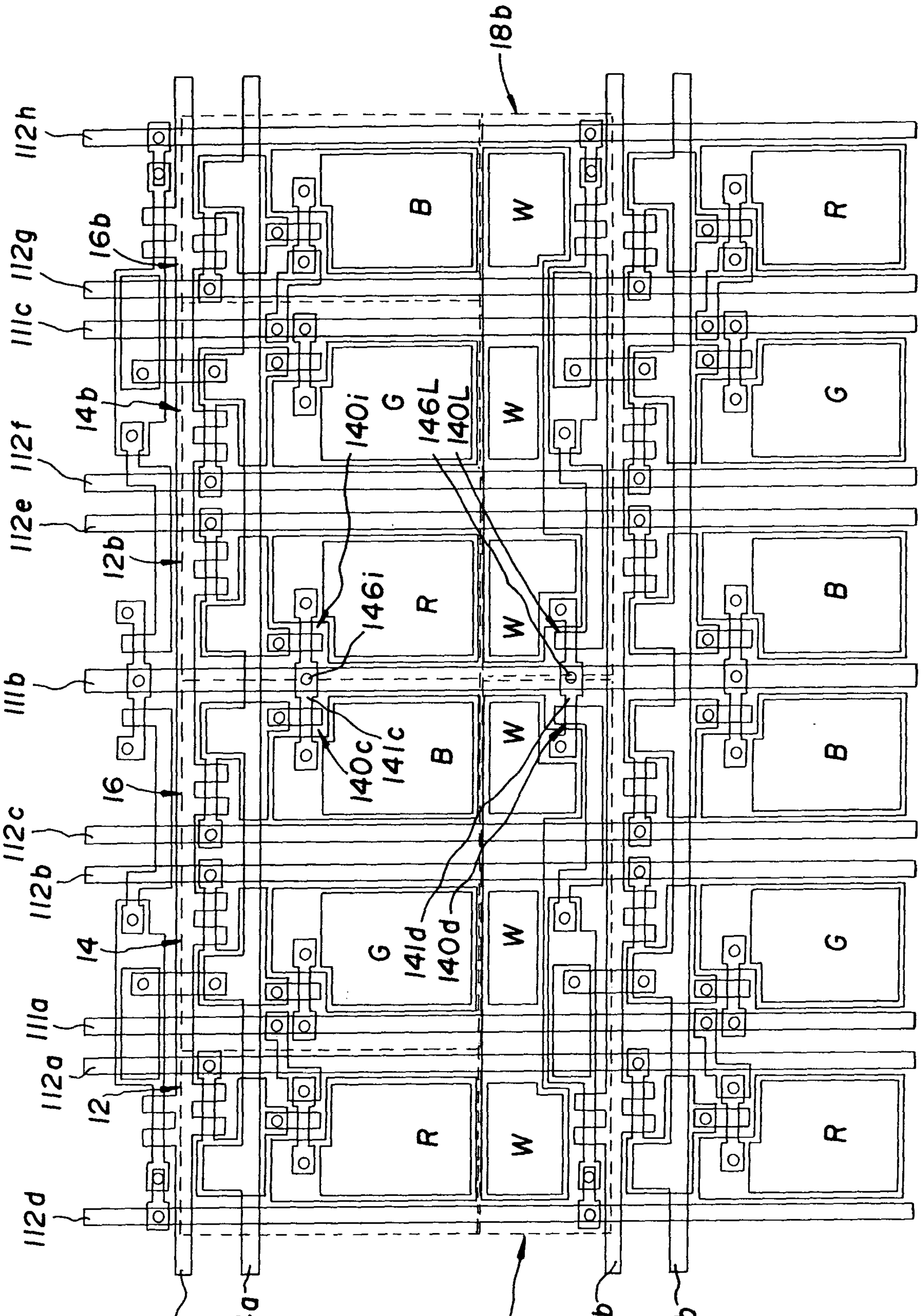

111b
112d
112a
112b
111a
112c
111b
112d
14
12
16
113a
114a
154
155a
122a
121a
R
G
B
18
W
W
W
131
153b
157a
156
157b
141b
113b
152
114b
153a
R
G
B
W
W
W

FIG. 15



18b
112h
112g
16b
111c
14b
112f
112e
12b
111b
16
112c
112b
14
111a
112a
12
112d
113a
114a
18
113b
114b
B
W
R
G
140i
146L
140L
146i
140c
141c
141d
140d

FIG.17

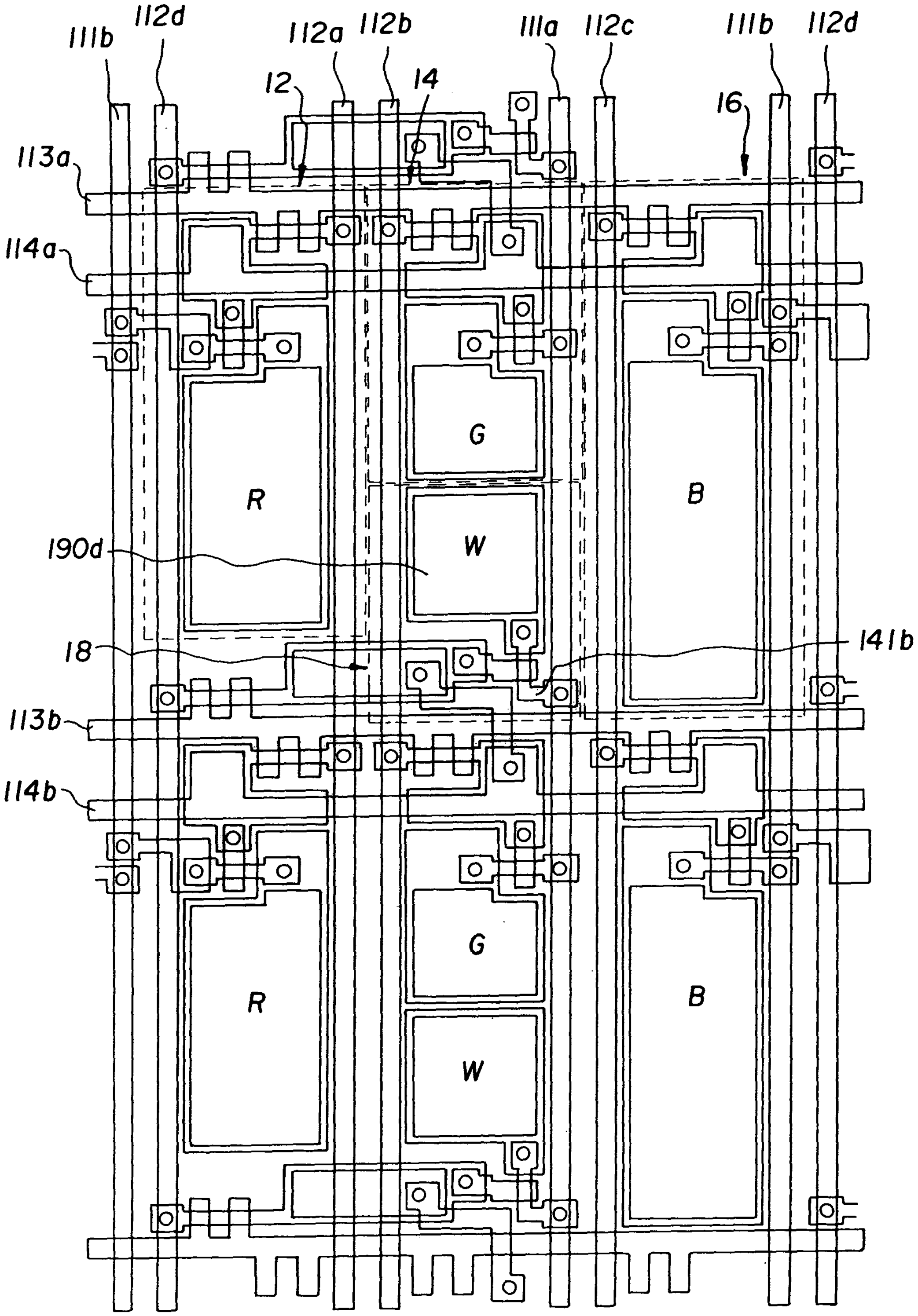

111b
112d
112a
112b
111a
112c
111b
112d
12
14
16
113a
114a
G
R
B
W
190d
18
141b
113b
114b
G
R
B
W

FIG. 18

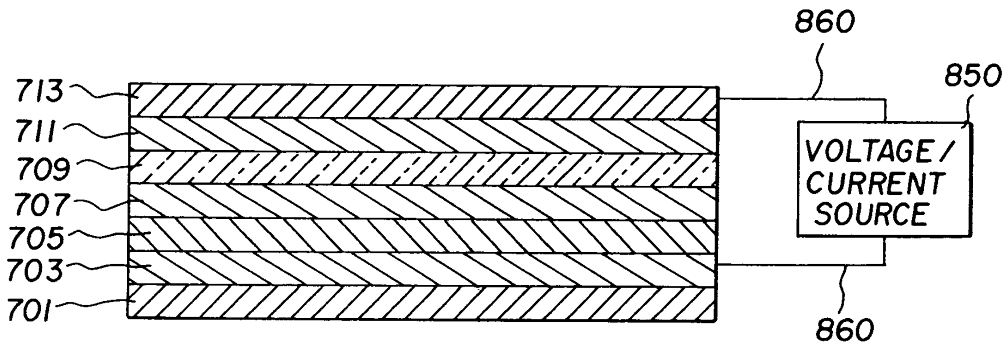


FIG. 19

PRIOR ART

专利名称(译)	彩色显示屏，提高了电源效率		
公开(公告)号	EP1473772A2	公开(公告)日	2004-11-03
申请号	EP2004076186	申请日	2004-04-19
[标]申请(专利权)人(译)	伊斯曼柯达公司		
申请(专利权)人(译)	伊士曼柯达公司		
当前申请(专利权)人(译)	全球OLED科技有限责任公司		
[标]发明人	COK RONALD S ARNOLD ANDREW D WINTERS DUSTIN L		
发明人	COK RONALD S. ARNOLD ANDREW D. WINTERS DUSTIN L.		
IPC分类号	H01L27/32 H05B33/12 G09G3/32 H01L51/50 H01L27/00		
CPC分类号	G09G3/3216 G09G3/3225 G09G2300/0452 G09G2300/0809 G09G2300/0842 H01L27/3213 H01L27/3216 H01L27/3218		
优先权	10/426299 2003-04-30 US		
其他公开文献	EP1473772A8 EP1473772A3 EP1473772B1		
外部链接	Espacenet		

摘要(译)

彩色OLED显示器包括发光OLED像素阵列（10），每个像素具有三个或更多个色域元件（12,14,16），用于发出指定色域的不同颜色的光，以及用于发出至少一个附加元件（18）。在色域内发射光的颜色，并且其中附加元件的功率效率高于三个或更多色域元件中的至少一个的功率效率;其中，显示器中每种颜色的所有色域元件在第一方向上排成一行，使得在该行中没有不同颜色的色域元件;其中，有色域元件在与第一方向垂直的第二方向上排成一行，使得色域元件的颜色在该行中交替;并且其中附加元件在第一和第二方向上排列成行。

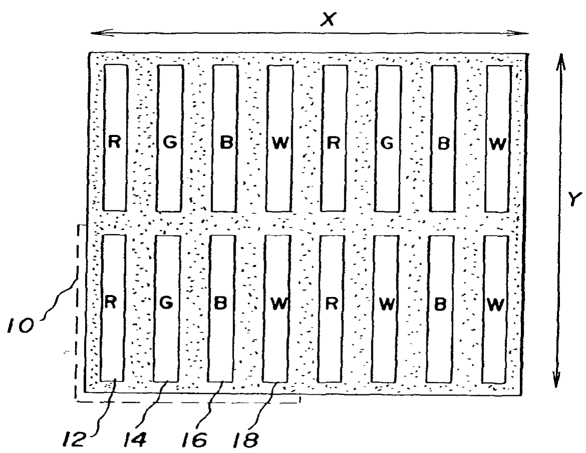


FIG. 1